DRAFT

WATER RESOURCES PLAN

Prepared for

Town of Buckeye
Buckeye, Arizona

July 12, 2010

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Prepared for
Town of Buckeye

VOLUME I
of the
TOWN OF BUCKEYE
INTEGRATED WATER RESOURCES PLAN

July 12, 2010

Brown and Caldwell Project No.: 135867

This is a draft report and is not intended to be a final representation of the work done or recommendations made by Brown and Caldwell. It should not be relied upon; consult the final report.

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LIST OF ACRONYMS

3-D	three-dimensional
ACC	Arlington Canal Company
ADES	Arizona Department of Economic Security
ADWR	Arizona Department of Water Resources
AFY	acre-feet per year
AMA	Active Management Area
ASR	Aquifer Storage and Recovery
AWS	Assured Water Supply
bls	below land surface
BWCDD	Buckeye Water Conservation and Drainage District *aka* BIC
CAGRD	Central Arizona Groundwater Replenishment District
CAP	Central Arizona Project
CAWCD	Central Arizona Water Conservation District
CAWS	Certificate of Assured Water Supply
CBWWTP	Central Buckeye Wastewater Treatment Plant
cfs	cubic feet per second
CIP	Capital Improvement Program
DAWS	Designation of Assured Water Supply
FRS	Flood Retarding Structure

LIST OF ACRONYMS (continued)

GFR	Grandfathered Right
GIS	Geographic Information System
gpcd	gallons per capita per day
gpm	gallons per minute
GSF	Groundwater Savings Facility
IGFR	Irrigation Grandfathered Right
LHSB	Lower Hassayampa Sub-Basin
MAG	Maricopa Association of Governments
MCL	maximum contaminant level
MGD	million gallons per day
mg/L	milligrams per liter
MPA	Municipal Planning Area
MPC	Master Planned Community
ppb	parts per billion
ppm	parts per million
PVNGS	Palo Verde Nuclear Generating Station
QA/QC	Quality Assurance/Quality Control
RID	Roosevelt Irrigation District
RO	reverse osmosis
SAT	soil aquifer treatment
SRV	Salt River Valley
TDS	total dissolved solids
USF	Underground Storage Facility
USEPA	Arlington Canal Company
USGS	United States Geological Survey
WESTCAPS	West Salt River Valley Central Arizona Project Subcontractors
WQARF	Water Quality Assurance Revolving Fund
WRF	Water Reclamation Facility
WSRV	West Salt River Valley
WUGB	Water Utility of Greater Buckeye
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

1. INTRODUCTION

The Town of Buckeye (the Town) is located near the far western boundary of Maricopa County, in south central Arizona. Its history as a center of agriculture dates back to the late 1800s, and it was incorporated in 1929 as a 440-acre town centered on what is now the downtown area. Until the 1990s, the Town's growth had been modest, consistent with a small, rural community profile. In the last decade, however, agricultural and native desert lands have been transformed into residential developments and commercial businesses at a rapid pace, and the Town's future planning includes the possibility of becoming an international trade and logistics center.

The unprecedented growth patterns of the last five to ten years have had significant impacts on the Town. The Municipal Planning Area (MPA) now encompasses 600 square miles (approximately 380,000 acres), straddles the Phoenix Active Management Area (AMA) boundary, and includes portions of four separate but interconnected groundwater basins: West Salt River Valley (WSRV), Lower Hassayampa, Gila Bend, and Rainbow Valley Basins (Figure 1-1). Not only is the Town faced with the challenge of managing diverse and separate groundwater resources, but the rules and regulations are vastly different for areas within versus outside of the AMA.

Interstate 10 (I-10) roughly bisects the MPA. South of I-10 the predominant land use is still agricultural, as shown on the aerial map on Figure 1-1, although residential, industrial and commercial land uses are intermixed with irrigated acreage. North of I-10 within the MPA boundary the land is largely native desert, interspersed with the early stages of development to the west and northwest of the White Tank Mountains. The property boundaries for Master Planned Communities (MPCs) and developments within and adjacent to the Town's MPA provide an indication of the changes that will occur in the future (Figure 1-2).

The timing and growth rate of the Town's MPCs and developments vary widely, and the majority of the development plans submitted to the Town are focused solely on the demands within each development footprint. A unified planning effort is needed to ensure that the water resources infrastructure, although initially comprised of disparate systems, will become a unified operation meeting the ultimate goal of interconnection.

1.1 Purpose and Goals

The purpose of the Integrated Water Resources Plan project is to develop a cohesive plan for moving forward, a starting point that serves as a repository for new and updated information. The underlying goals of the project are to facilitate the process of managing the growth in a consistent, unified way and to develop water management guidance documents for Town staff, developers, and residents.

Prior to this project, a compilation of the planning data had not been done, nor had hydraulic modeling been performed to assess the integration of neighboring systems. Several studies considered the management of multiple developments under a single, sub-regional plan; however, this project provides the Town with a starting point for eventually combining all development data and plans in a single repository. Moving forward, as changes and revisions to existing development plans are submitted, and as the Town signs new development agreements, the data will be incorporated into the framework developed in this Plan.

Specific goals and objectives of the Integrated Water Resources Plan were defined in conjunction with Town staff and include the following:

- Assess water resources in the context of long-term sustainability;
- Develop a management tool to plan for future water and wastewater service, with a specific focus on planning and development in the Central Buckeye region;
- Develop Capital Improvement Program (CIP) plans for water and wastewater to identify critical infrastructure needs in the Central Buckeye region; and
- Provide basic planning documents that will support the Town's efforts to secure a Designation of Assured Water Supply (DAWS) from the Arizona Department of Water Resources (ADWR).

The Town submitted a DAWS application in December of 2008. The application is currently under review by ADWR, with approval of the application anticipated in 2010 or 2011. The Integrated Water Resources Plan is a key planning element that will support future modifications to the DAWS.

1.2 Scope of Work

The Town developed separate scopes of work for a Water Master Plan and a Wastewater Master Plan in 2008, both of which included elements of water resources planning. Brown and Caldwell was selected to develop both plans, and began a 6-month collaboration process with Town staff to combine the scopes of work into an Integrated Water Resources Plan that included three distinct planning elements: a Water Resources Plan, a Water Master Plan, and a Wastewater Master Plan. Through this process, a sequence of tasks was defined for the project; the flowchart is provided as Chart 1 at the end of this section.

The scope of work for the Integrated Water Resources Plan is provided as Appendix A. As the project progressed, adjustments to scope items were made to address issues and data gaps as necessary; these revisions are reflected in the scope of work in Appendix A.

The Water and Wastewater Master Plans were similar in methodology and scope, and were therefore combined into a single document; the different purpose, study area, and goals of the Water Resources Plan were better served in a separate report:

- Volume I Water Resources Plan
- Volume II Water and Wastewater Master Plan

1.3 Data Sources

Initial data collection was performed during the first six months of the project, from July through December of 2008. All planning documents were provided by Town staff in electronic format, if available, or in hard copy or scanned hard copy format otherwise. The data collection task was extended to address issues of data compatibility, and to allow for mapping and digitization of key infrastructure elements. This process was largely completed by Town staff using a Geographic Information System (GIS), following industry-accepted protocols and data standards. Brown and Caldwell provided Quality Assurance/Quality Control (QA/QC) on the work product.

Water, wastewater, reclaimed water, and water resources plans for the MPCs and developments within the Buckeye MPA were provided by the Town. A comprehensive list of the plans utilized for the project is provided in Appendix B. The most recent versions of the plans and documents available in early 2009 were utilized for the project, whereas more recent submittals to the Town will not be reflected in this work. In addition, the project relied heavily on key planning documents for the region, including:

- 2007 Town of Buckeye General Plan Update (Adopted January 18, 2008)
- Town of Buckeye Water Conservation Plan (June 2, 2009)
- Maricopa Association of Governments (MAG) 208 Water Quality Management Plan - Comprehensive Amendment for the Town of Buckeye (October, 2007)
- Buckeye Parks, Open Space, and Trails Plan (November, 2005)
- Land Use Plan from the Buckeye General Plan (Figure 1-2)
- MAG Transportation Systems Modeling for Buckeye Region (Procured November 2009)
- Economic Development Fact Book, Town of Buckeye, Arizona (Revised 09-2008)

1.4 Approach

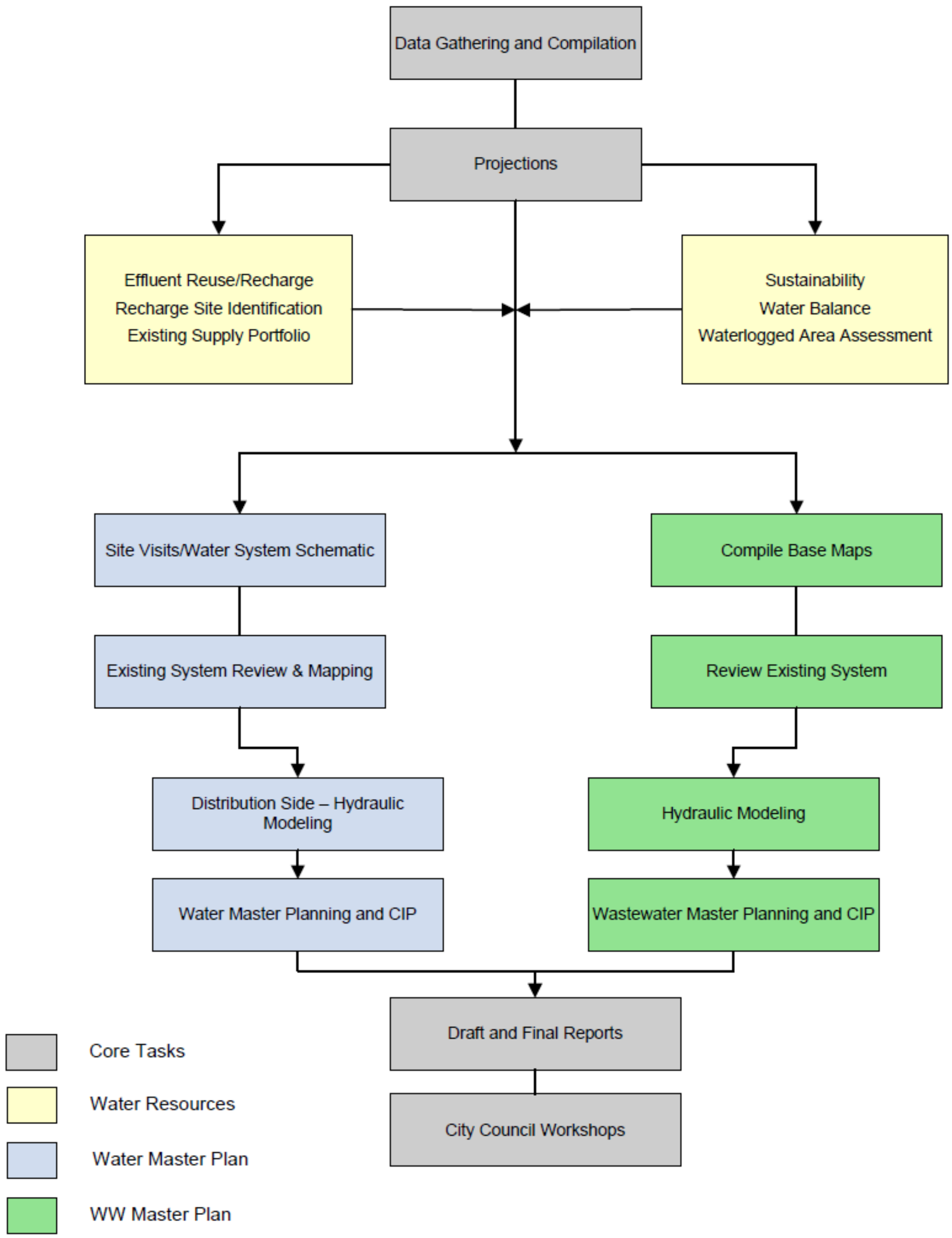
The scope initially developed for the project in early 2008 preceded a nationwide economic recession by several months. When the notice to proceed was issued in July 2008, all projections (for future population growth, development, and land use) were predicated upon the assumption of a continuation of the tremendous growth that had previously characterized the region. During the course of this project, radical changes in population growth and development trends have occurred that generate uncertainty as to the timing and the magnitude of future growth. To the extent possible, the scope of work for this project has been adapted to address changing economic conditions and to provide the Town with a suitable starting point to manage their current and future water, wastewater, and water resources.

The original scope specified four planning horizons for water and wastewater hydraulic modeling – 2007, 2010, 2020 and buildout – and a 100-year timeline for water resources modeling (consistent with ADWR Assured Water Supply [AWS] regulations). These planning horizons were adjusted during the course of the project as the interim projections were no longer deemed to be realistic. Planning horizon data for 2007 were used to represent the present-day planning horizon, and were augmented with 2008 data where feasible. Projections for 2010 were used, but are referred to as the short-term planning horizon for purposes of the hydraulic infrastructure modeling and CIP plans. The 2020 planning horizon data were not considered during this study. Buildout planning assumptions remained unchanged as they are on a sliding scale and are not tied to a specific year. Thus, the timeline for the Integrated Water Resources Plan is focused on short-term and buildout horizons.

Study areas for each of the three components of the Integrated Water Resources Plan (water resources, water infrastructure, and wastewater infrastructure) were varied to address the key areas and issues. The water and wastewater components were focused on the central Buckeye region, between I-10 and the Gila River, while the water resources component was broader based, covering the majority of the Buckeye MPA and excluding only the Verrado region and locations south of the Buckeye Hills. In this manner, the most immediate infrastructure needs in central Buckeye were evaluated, and long-term water resources planning encompassed the bulk of the groundwater aquifer system most crucial for the Town's future water supply portfolio.

Both volumes of the Integrated Water Resources Plan are intended to be updated on a periodic basis. They are evolving documents and their value is dependent upon up-to-date assumptions, inputs, and planning. Typically, 5-year intervals are recommended for water and wastewater master plans; however given the fluctuations in the current economic climate, an update within the next 3 years would be advised. The water resources plan will require an update within the same timeline.

Chart 1. Integrated Water Resources Plan Flowchart



2. BACKGROUND

The study area for the Water Resources Plan is the active model domain for the Hassayampa model, shown on Figure 2-1. The property boundaries shown on Figure 2-1 represent all MPCs or developments that currently have a development agreement with the Town.

The Town MPA can be divided into four separate planning areas based on geographic, physical, regulatory, and land use differences: Central Buckeye (from the Gila River north to I-10); the Verrado region; the Hassayampa River region north of I-10; and the region south of the Buckeye Hills. The study area for the Water Resources Plan excludes the regions in and around Verrado and the portions of the MPA that are located south of the Buckeye Hills in Gila Bend and Rainbow Valley Basins. With the exception of the proposed 375-megawatt Sonoran Solar Energy Project, the region south of the Buckeye Hills is not anticipated to experience significant growth over the next 5 years, and is located in a separate groundwater basin from the rest of the Town's MPA. It is also outside of the Phoenix AMA, and growth-related water use is therefore subject to different regulations than the rest of the Town's planning area. Verrado and neighboring developments are served by Arizona American Water Company and are located in a portion of the WSRV Sub-Basin that is partially isolated from the rest of the Town's aquifer system. Thus, the study area for the Water Resources Plan encompasses the main aquifer system that the Town will manage for its major source of water supply.

In this report, there are references to regions or features that are distinguished by spatial extent, topography, geology, or land use, as follows:

1. Central Buckeye: The area within the Town MPA that is between I-10 and the Gila River, which includes historic (downtown) Buckeye.
2. Verrado Region: The portion of the Town's MPA that is located east of the White Tank Mountains in the WSRV Sub-Basin, including the Verrado MPC and neighboring developments.
3. South of Buckeye Hills: The portion of the Town's MPA that is separated from the rest of the planning area by the Buckeye Hills. This region is located in the Gila Bend Basin (a separate aquifer system), and is outside of the Phoenix AMA.
4. Hassayampa River Region north of I-10: An area of significant projected growth, this region comprises the northern portion of the Town's MPA and is predominantly composed of MPCs in various stages of development.
5. Buckeye MPA: The Buckeye MPA comprises approximately 600 square miles and includes portions of: the Lower Hassayampa, WSRV, and Gila Bend Sub-Basins.
6. The "Neck": The Neck is a particularly sensitive and hydrogeologically significant area located in the central portion of the Lower Hassayampa Sub-Basin (LHSB) at the pinch-point between the Belmont and White Tank Mountains, where the groundwater basin both narrows and thins.
7. Gila River corridor: The Gila River corridor is the river reach between the White Tank Mountains and the Buckeye Hills that historically has been farmed. In the study area, the Gila River corridor begins east of the White Tank Mountains and extends downstream to Gillespie Dam.

8. The "waterlogged" area: The waterlogged area is a sub-region of the Gila River corridor located immediately adjacent to the river within the irrigation district boundaries of the Buckeye Water Conservation and Drainage District (BWCDD) and the Arlington Canal Company (ACC). Groundwater levels in this region have consistently been at or near land surface, requiring the installation of dewatering wells for agricultural production purposes in the late 1960s.
9. Tonopah Region: This area is located near the community of Tonopah in the arid plain south of the Belmont Mountains. The majority of this region will be served by one of Global Water's subsidiaries.
10. Active Model Area or Active Model Domain: The active model area or active model domain for the Hassayampa model defines the extent of the alluvial aquifer system, and comprises approximately 880 square miles (Figure 2-1).

2.1 Service Areas and Other Water Providers

Buckeye's existing water service areas in relation to other water providers within or adjacent to the MPA boundary are shown on Figure 2-2. The Town operates five separate and distinct service areas within the study area: Central Buckeye, Sundance, Tartesso, Buckeye Municipal Airport, and Festival Ranch. The total distance from the Central Buckeye service area to the Festival Ranch service area north of the White Tank Mountains is approximately 28 miles.

The Town provides both water and sewer service for Central Buckeye, Sundance, Tartesso, and Festival Ranch. In addition, the Central Buckeye Wastewater Treatment Plant (WWTP) provides sewer service for Valencia, which is located in Global Water's water service area.

Municipal water providers who border the Town's MPA include the Cities of Surprise, Goodyear, and Peoria (Figure 1-1). Private water providers neighboring the Town's existing and future service areas include: the Water Utility of Greater Tonopah (Global Water); Litchfield Park Service Company, Allenville Water Company and the community of Hopeville; the Water Utility of Greater Buckeye (Global Water); the City of Surprise; Valencia (Global Water); Arizona Water Company; and Arizona American Water Company (Figure 2-2).

2.2 Water Supply

The Town's water supply portfolio is highly dependent upon groundwater; this source of supply was used to satisfy 68 percent of the Town's water demands in 2007 and 2008. The Town has rights to a small amount of Central Arizona Project (CAP) water, a renewable surface water resource; however, in terms of annual magnitude it is a minor right (currently 363 acre-feet per year [AFY]), that decreases annually until it reaches 25 acre-feet in 2034. The Town is actively pursuing an additional CAP allotment.

Irrigation district water deliveries and an ever-increasing supply of treated effluent are the remaining sources of supply for the Town, representing approximately 30 percent and 12 percent of the Town's water supply portfolio, respectively, in 2009. The future dependence on groundwater could be a major limitation imposed on the Town's growth, underscoring the need and providing the incentive to implement sound water resources management policies.

2.3 Designation of Assured Water Supply

The Town submitted a DAWS application to ADWR in December of 2008. The application is currently under review by ADWR. The Town plans to be a designated provider for all regions within the Town's MPA with the following exceptions:

- Areas served by other water providers including Global Water and its subsidiaries, Arizona-American Water (Verrado), Arizona Water, and the community of Hopeville;
- The portion of Buckeye's planning area south of the Gila River along SR-85, (this area will not be covered by the DAWS because it is outside the Phoenix AMA);
- The area south of the Gila River in Rainbow Valley, within the Gila Bend Basin. This area was not included in the 2008 DAWS application because a separate groundwater model will be required. Eventually this region can be included in the Town's designated service area.

Designation status is an important aspect of the Town's management plan, as it gives the Town more authority and flexibility in the management of water resources. Without the designation, the Town cannot receive long-term storage credits for recharging CAP water; this has precluded the Town from using its CAP allotment. The Town is currently exploring the potential for securing additional CAP water to augment groundwater supplies. Procuring the designation will enable the Town to receive recharge credits for its current and any future CAP allotments, as well as for excess CAP water the Town may purchase. As the Town accumulates credits, it will be able to offset a portion of the Central Arizona Groundwater Replenishment District (CAGRD) fees.

As a designated provider, the Town will pay replenishment fees directly to CAGRD and customers will no longer pay these fees as part of their property taxes. A line-item fee may be added to water bills to cover the replenishment fees, which will be applied to all subdivisions regardless of when they were platted. Subdivisions platted prior to 1995 are currently exempt from replenishment fees, but all groundwater pumping within the AMA will have an associated replenishment obligation when the Town receives designation status. However, the Town will be able to accrue long-term storage credits to reduce the replenishment fees. In the long term, this will result in cost savings to property owners and to the Town.

When the Town becomes a designated provider, developers will be able to sell lots without obtaining a Certificate of Assured Water Supply (CAWS) or enrolling in the CAGRD. They will not have to pay CAGRD enrollment fees (currently $107 per housing unit) or replenishment reserve fees (currently $47 per acre-foot). This is a substantial economic benefit for smaller developments as it eliminates enrollment and replenishment reserve fees, and the costs of securing individual approvals of AWS.

The designation status is typically reviewed by ADWR every 10 years (ADWR is required to review a designation every 15 years at a minimum). In addition, revisions to the application must be made by the Town to update and increase their water demands, revise projections, and generally plan for the future. For these reasons, a Designation of Assured Water Supply is a status viewed favorably by the state, potential investors, and businesses as it signifies responsible stewardship of water resources.

2.4 Master Planned Communities and Developments

All MPCs and development boundaries in the region are shown on Figure 2-3. This figure shows all developments that currently are, or will be, served by the Town as well as developments that will be served by other providers. The anticipated future growth in the region is evident from the areal extent of the development boundaries.

North of I-10, Tartesso and Sun City Festival Ranch are the only MPCs that have completed the first phase of development, with active service areas for water and wastewater.

2.5 Existing Land Use

Existing land use and hydrologic features in the region are shown on Figure 2-4; land ownership is shown on Figure 2-5. The distribution of agricultural lands in the region is evident from the aerial basemaps on these figures. Three major irrigation districts operate in the central Buckeye region: the BWCDD, the ACC, and the Roosevelt Irrigation District (RID). The boundaries of the lands served by BWCDD and RID and the major canals for all three entities are shown on Figure 2-4. An extensive network of laterals (small canals or ditches) is linked to these major canals, and may provide a means to route and serve water for the Town in the future.

A total of four power plants operate in the region (Figure 2-4): Palo Verde Nuclear Generating Station (PVNGS); Arlington Valley Energy Facility (Duke Energy); the Mesquite Power Generating Station (Sempra Energy Resources); and the Redhawk Power Plant (Pinnacle West Energy). The plants are generally located in the southwestern portion of the study area in the vicinity of Centennial Wash near the Palo Verde Hills.

2.6 Hydrology and Hydrogeology

Hydrologic features are presented on Figure 2-4, including the Gila and Hassayampa Rivers, the extent of the waterlogged area, the central Buckeye irrigation district canals, existing recharge facilities, and a series of Flood Retarding Structures (FRSs) owned and operated by the Flood Control District of Maricopa County.

2.6.1 Gila and Hassayampa Rivers

The Gila River flows from east to west through Central Buckeye. At Arlington, the river makes an abrupt 90-degree turn southward into the Gila Bend Basin. Gillespie Dam, a storage and diversion structure, is located at the boundary between the Lower Hassayampa and Gila Bend Basins. Since 1922, flow has been regulated in the Gila River; upstream conditions and management practices therefore impact the hydrologic system in the Buckeye area.

Currently, flow in the Gila River is considered to be perennial from the Salt-Gila confluence to the BWCDD canal diversion (near Bullard Road) due to discharge of treated effluent from the City of Phoenix 91st Avenue WWTP. A portion of the flow in the Gila River is diverted into the BWCDD canal; at certain times of the year, all flow is diverted. Downstream, however, the high water levels in the region cause groundwater to discharge to the river, returning some of the irrigation return flows and incidental recharge from irrigated lands. In the Buckeye region, flow in the Gila River is thus comprised of storm water runoff, irrigation return flow, contributions from groundwater, water released from upstream dams, and treated effluent.

The Hassayampa River flows from north to south in the study area, entering the sub-basin via a narrow fault-controlled reach in the Vulture Mountains, and eventually merging with the Gila River near Arlington (Figure 2-4). The reach of the Hassayampa River within the study area flows only in response to precipitation events. According to the U.S. Geological Survey (USGS), flows for the northern reaches range from "a few 10s of cubic feet per second (cfs) during the winter rains, to huge, short-term, storm water runoff events that produce in excess of 10,000 cfs" (Burt Duet, USGS, personal communication, 2005). Hassayampa River flows rarely reach the confluence with the Gila River, as water rapidly infiltrates into the sandy riverbed material. A comparison of stream gage data for the Morristown stream gage (northern portion of the sub-basin) versus the Arlington gage (in the southern portion of the sub-basin, just upstream of the confluence with the Gila River), indicates that river flows below 1,000 cfs generally do not reach the downstream Arlington gage.

2.6.2 Major Washes

Two major washes carve a path through the region (Figure 2-4). To the north, Jackrabbit Wash drains a large portion of the northwestern MPA and discharges to the Hassayampa River near the pinch point between the Belmont and White Tank Mountains. In the southwest, Centennial Wash flows into the region from the Harquahala Basin and joins the Gila River south of Arlington. Both washes are ephemeral, flowing only in response to recharge events.

Numerous other small drainages are present, draining the Vulture, Belmont, White Tank, and Hieroglyphic Mountains. Of these, Waterman Wash and Stone House Wash are sites for future permitted recharge or permitted emergency discharge of treated effluent. Wagner Wash is currently being used for discharge of treated effluent from the Festival Ranch Water Reclamation Facility (WRF) (Section 9.0).

2.6.3 Irrigation Districts

All three of the irrigation districts operating within the Buckeye MPA boundary are located south of I-10 between the freeway and the Gila River (Figure 2-4). The canals generally form the boundaries for each district, with their service areas located south of the respective canal. RID is the furthest north, BWCDD borders RID on the south, and ACC lands are adjacent to the river immediately above Gillespie Dam. All three canals move water from east to west (and then south, in the case of ACC), and any irrigation water that is not picked up by district farmers is routed back into the river.

The majority of the water supply for BWCDD and RID is imported from outside the Buckeye MPA. The main source for BWCDD is 91st Avenue WWTP effluent which is routed via the Gila River and diverted into their canal heading approximately 0.3 miles east of Bullard Road. RID canal water is a mix of several sources; one of the primary sources is groundwater pumped from a well field in Tolleson.

ACC water is also a mix of supply sources, some of which are imported. Sources include Gila River water, irrigation return flows from fields to the north, treated effluent from the Central Buckeye WWTP (CBWWTP), and natural runoff.

2.6.4 Waterlogged Area

The waterlogged area is a buffer zone along the Gila River that extends for approximately 35 miles from its eastern boundary at 99th Avenue in Phoenix, to its western terminus in the Buckeye MPA south of Arlington, at Gillespie Dam. This region traverses portions of western Phoenix, southern Avondale, and southern Goodyear as well as that portion of the Buckeye MPA along the Gila River corridor, and reaches a maximum width of approximately 5 miles wide at its widest point. Approximately 24 miles of the total 35-mile extent of the waterlogged area (70 percent) is within the Buckeye MPA (Figure 2-4).

Gillespie Dam, located at the southern tip of the LHSB, was built in 1921. The dam was designed as a storage and diversion structure to support irrigated lands to the south, and its construction is reported to have caused a 22-foot rise in groundwater levels along the Gila River corridor near Arlington.

A waterlogged area along this stretch of the Gila River has been documented since the early 1920s, and its persistent presence is attributed to:

- the construction of Gillespie Dam and the resulting restrictions on surface water and groundwater flows out of the sub-basin;
- recharge from irrigation canal leakage and irrigation return flow;
- recharge from irrigated lands along the Gila River corridor;
- recharge along the Gila River from discharge of treated effluent from the 91st Avenue WWTP (Halpenny, 1982 and 1987; Errol L. Montgomery and Associates, 1988 and 2000);
- the region's location as the surface water and groundwater confluence for the Lower Hassayampa and WSRV Sub-Basins; and
- the importation of groundwater for irrigation that is pumped outside of the region and imported via irrigation canals. This imported groundwater adds water to the aquifer system through canal leakage and recharge without the balancing effect of localized pumping.

Due to these influences, groundwater is at or near land surface in the region, enabling a high degree of interconnection between the surface water and groundwater systems. Gillespie Dam was breached in January 1993, and water levels were reported to have dropped slightly in the immediate vicinity. Although a portion of the structure was washed away, a constriction of surface flow still exists.

2.6.5 Groundwater Flow

Figure 2-6 is a water level contour map that shows the general north/south direction of groundwater flow. The water level contours and groundwater elevations presented on Figure 2-6 are based on 2006 and 2007 water level measurements from the ADWR Groundwater Site Inventory database. Impacts of agricultural pumping and recharge on water levels and contours are evident in the vicinity of irrigated lands in the Tonopah region, along the Gila River corridor, and near Centennial Wash.

The LHSB is hydraulically connected to the adjoining WSRV Sub-Basin both north and south of the White Tank Mountains. As indicated by the water level contours in the north, groundwater flows southward and diverges around the White Tank Mountains. In essence, the WSRV receives a portion of the sub-basin inflows derived from Hassayampa River infiltration and mountain front recharge.

Although irrigation-related recharge is significant in the Central Buckeye region, the major sources of groundwater recharge for the northern portion of the sub-basin are mountain front recharge and infiltration of Hassayampa River flows. The combined, long-term, annual average for these two sources of natural groundwater replenishment is estimated to be approximately 32,000 AFY (Brown and Caldwell, 2006). For all developments north of I-10, both within and outside of the Buckeye MPA, this represents the natural renewable portion of the regional groundwater supply. For perspective, this is comparable to estimated long-term recharge from the Gila River, which is approximately 30,000 AFY.

In the central portion of the LHSB between the Belmont and White Tank Mountains, groundwater flow is constricted, causing higher flow gradients (i.e., water level contours located closer to each other). Once past this constriction, flow once again diverges to the west toward Tonopah, to the southwest toward the Centennial Wash region, and to the south along the Hassayampa River corridor toward Central Buckeye.

South of the White Tank Mountains, groundwater from the WSRV moves westward along the Gila River corridor, merging with groundwater migrating southward along the course of the Hassayampa River. Groundwater from these two sources eventually flows across a transect extending from the Palo Verde Hills to Arlington, moving south toward the outflow location near Gillespie Dam or southwest into the Centennial Wash cone of depression (Figure 2-6).

The extremely limited, natural recharge of the groundwater supply and the groundwater flow patterns in the region underscore the need to collaborate with neighboring municipalities and water providers on the management of water resources.

2.6.6 CAP Canal and Existing Recharge Facilities

The CAP canal cuts through the central portion of the LHSB, oriented from southwest to northeast as it emerges from the Belmont Mountains and heads north around the White Tank Mountains. The canal delivers Arizona's Colorado River water to Phoenix and Tucson.

Three recharge facilities located along the CAP canal are actively recharging in the study area (Figure 2-4). The Tonopah Desert and Hieroglyphic Mountains Recharge Projects are owned and operated by CAP and recharge four categories of CAP water: (1) water stored for cities and private water companies who will eventually recover and use it; (2) water stored to satisfy replenishment obligations for the CAGRD, (3) water stored by the Arizona Water Bank Authority against future shortages and for interstate water banking purposes, and (4) storage of excess CAP water. The Hassayampa River linear recharge facility is owned by Summit Management and stores excess CAP water to earn long-term storage credits which can be sold or used to recover stored water in the future.

The Town owns one recharge facility in the study area, located at the Tartesso property. The Tartesso recharge facility, which stores treated effluent from the Tartesso West WRF, is permitted for 20,163 AFY and has been operating since 2007.

The last recharge facility in the study area is located within the Town's planning area, but is owned by Arizona American Water. This facility consists of vadose zone wells recharging effluent from the Verrado WRF. Recharge began in 2007, and the facility is permitted for up to 500 AFY.

3. POPULATION

The Town of Buckeye has grown dramatically in areal extent and population since its incorporation as a 440-acre community in 1929, with the majority of this growth occurring in the last 10 years. Until recently, future growth was projected to follow the trends over this last decade, culminating in an ultimate population between 1.5 and 2.0 million people (2007 General Plan Update; 2007 MAG 208 Plan Amendment).

Population projections are a crucial element for master planning. Projected growth rates and the buildout population are the basis for wastewater flow projections, water demand, and ultimate capacity planning. In this section, historic population and growth are presented, and the changes in recent trends are discussed. Buildout population projections are compared to MAG population projections through 2030 to evaluate and modify the original planning horizons defined in the scope of work (Appendix A).

3.1 Historic Population and Growth Rates

Table 4-1 presents census population from 1970 through 2005 and the acreage of the Town's annexations for the same period. Between 1970 and 2000, the population growth rate ranged from 3 to 5 percent per year. Growth in the 5-year period from 2000 to 2005 increased dramatically to approximately 58 percent per year. While an impressive increase, this does include the impacts of the expansion of the Town's annexed boundary, which doubled in size. The current Town boundary encompasses over 235,000 acres (Figure 1-1).

Table 3-1. Town of Buckeye Census Population and Annexations 1970-2005

Year	Population	Percent Growth for the Period	Average Population Growth Per Year	Town Boundary (Total Annexed Acres)
1970	2,599	--	--	n/a
1980	3,434	32%	3%	n/a
1990	5,038	47%	5%	11,904
2000	6,537	30%	3%	81,344
2005*	25,406	289%	58%	142,719
2010	--			235,361

*Sources: U.S. 1970, 1980, 1990 and 2000 Census Population; *Town of Buckeye Economic Development Fact Sheet*

Yearly population estimates from 2001 through 2009 from the Arizona Department of Economic Security (ADES) are presented in Table 3-2. The population figures are roughly comparable to the census data for the period from 2000 through 2005. The 2009 estimate from ADES reflects the current economic recession but still projects a slight increase in population relative to the 2008 estimate. Economic indicators from the Town suggest that population has dropped since late 2008; current population is assumed to be at or near the 2007 level of 40,467 residents.

Table 3-2. Town of Buckeye Population Estimates 2001-2009		
Year	Population	Percent Growth per Year
2001	10,650	25%
2002	11,955	12%
2003	13,065	9%
2004	14,540	11%
2005	23,955	65%
2006	31,745	33%
2007	40,467	27%
2008	50,143	24%
2009	52,764	5%

Source: Arizona Department of Commerce, 2010

The databases used in support of the Integrated Water Resources Plan reflect 2007 and 2008 groundwater pumping, land use, billing, water use, and wastewater flows. For consistency, the 2007 population estimate of 40,467 was used as a basis for calculations and assumptions, representing both 2007 and 2008 population. Until 2010 census data are available, this estimate is considered to be a rough approximation of present-day population.

3.2 Land Use Plan and Population Projections

Buckeye's General Plan (Town of Buckeye, 2007) included population projections based on the buildout land use, acreage within each land use category, and assumptions regarding population density. The areal distribution of each land use category is shown on Figure 1-2. The land use acreages were updated for this project to reflect revisions to the MPA boundary and land uses that post-date the General Plan (Table 3-3).

Table 3-3. Total Acreage in the Buckeye Municipal Planning Area by Land Use Category	
Land Use Category	Acres
Very Low Density Residential	29,739
Low Density Residential	64,392
Medium Density Residential	85,061
Medium High Density Residential	9,904
High Density Residential	4,370
Mixed Use	14,449
Verrado - Master Planned Community	8,795
Festival Ranch - Master Planned Community	10,407
City Center	1,151

Table 3-3. Total Acreage in the Buckeye Municipal Planning Area by Land Use Category	
Land Use Category	**Acres**
Regional Commercial	15,309
Professional Office Employment	3,075
Open Space	102,761
Military	1,438
Industrial	11,114
Government Center	56
Community Commercial	2,658
Business Park	14,107
TOTAL	**378,786**

Based on the updated acreage from Table 3-3 and assumptions regarding percent of developable acres, density, and persons per household from the General Plan, an updated buildout population was calculated (Table 3-4). Where there was a range given for the density of a residential land use type in the General Plan, the midpoint of the range was used for this calculation. Total buildout population for the Town of Buckeye based on these assumptions is 1,847,516 residents.

Table 3-4. Land Use Categories and Projected Population at Buildout					
Land Use Category	**Acres**	**Percent Developed**	**Density (Dwelling Units/Acre)***	**People/ Household**	**Buildout Population**
Very Low Density Residential	29,739	80%	0.5	2.7	32,118
Low Density Residential	64,392	80%	2.0	2.7	278,173
Medium Density Residential	85,061	80%	4.5	2.7	826,788
Medium High Density Residential	9,904	80%	8.0	2.7	171,135
High Density Residential	4,370	80%	12.5	2.7	117,986
Mixed Use	14,449	80%	10.0	2.7	312,106
Verrado - Master Planned Community	8,795	80%	1.6	2.7	30,396
Festival Ranch - Master Planned Community	10,407	80%	2.4	2.7	53,952
City Center	1,151	100%	8.0	2.7	24,862
TOTAL	**228,268**	**--**	**--**	**--**	**1,847,516**

**Density used for population calculation is the midpoint of ranges cited in the Town of Buckeye General Plan (2007)*

3.3 Planning Horizons

The original scope of work specified four planning horizons for water and wastewater hydraulic modeling: 2007, 2010, 2020, and buildout. For water resources modeling, a 100-year timeline was specified, which is consistent with the current regulatory framework. These planning horizons were adjusted during the course of the project to capture more recent trends not yet reflected in published population projections from MAG, which publishes every 5 years. The most recent MAG projections were published in 2007, compiled during the prior year, and thus assumed rapid growth patterns that were in keeping with trends from that time period (Table 4-5). Those rapid growth trends are no longer viable predictors for the Town's planning horizons. Alternative approaches were therefore utilized for this project, including the Town's most recent population projections from the 2008 DAWS application and buildout population projections from the Town's General Plan.

Table 3-5. Comparison of Population Projections 2010-2020

Year	2008 DAWS Application Population	MAG Population	Percent Difference MAG versus DAWS Population
2010	50,000	95,695	+91%
2020	225,000	275,674	+25%
2030	375,000	537,490	+43%

DAWS = Designation of Assured Water Supply, December 2008
MAG = Maricopa Association of Governments

The Town's Water Resources Department developed population projections in support of their DAWS application submitted in December 2008. These datasets were compiled less than two years after the 2007 MAG projections, but a comparison of MAG estimates with the more recent data from the Town (Table 3-5) reflects the significant changes that have occurred during this period. The 2010 projection from MAG is almost double the more current estimate derived by the Town. Based on changes in occupancy rates since 2008, the DAWS estimate of 50,000 residents is still slightly high. The difference in 2030 population projections is not as significant but there is again a substantial divergence between these two sources.

Recovery from the economic recession and a return to a more stable economy is predicted for Arizona (University of Arizona, 2010), although a more conservative growth pattern relative to the previous decade is anticipated. The explosive rate of construction and home sales of the last 10 years should not be projected into the future for planning purposes when the reality is a trend toward downsizing buildout densities and population estimates.

The original planning horizons of 2007, 2010, 2020, and buildout were therefore revised for the water/wastewater hydraulic modeling and CIP to account for slower growth and uncertainty associated with population projections. The 2007 population data were used to represent the present-day planning horizon and were augmented with 2008 data where feasible. All indications from the Town suggest that the 2007 data are also representative of 2010 conditions. Planning for 2010 is based on a population estimate of 50,000 residents and is considered to be a short-term planning horizon for purposes of the hydraulic infrastructure modeling and CIP plans. The 2020 horizon was eliminated altogether because MAG population projections and the associated spatial distribution of growth for 2020 were too out-of-date to warrant a separate planning horizon. The planning horizons for the hydraulic modeling and CIP planning are therefore focused on 2010 for short-term infrastructure and buildout for the ultimate long-term infrastructure.

3.3.1 Buildout Projections

The buildout planning horizon is a relative timeframe and is not tied to a specific year. It is, however, the most crucial planning horizon, as all interim year planning and the CIP are dependent upon the ultimate buildout infrastructure requirements. Land use from the 2007 General Plan incorporates planning documents from individual developments and MPCs to the extent feasible. The land use data, although generalized, are the best spatial representation of the long-term distribution and magnitude of residential properties for the Town. However, the population projections based on the land use categories assumes maximum usage of acreage within each residential category (Table 3-4). In many cases, these population projections are higher than individual development plans.

As the most comprehensive future planning tool, General Plan population projections were utilized for water and wastewater hydraulic modeling in Volume II of this Plan. The hydraulic modeling and CIP were restricted to that portion of the MPA south of I-10 and north of the Gila River, and were designed with the flexibility to easily revise or scale back the population and model demands in the future. It is anticipated that developments north of I-10 will be incorporated into these models as new and revised plans are submitted to the Town in the future.

As for the buildout population projections, the Sustainability Assessment described and discussed in Section 6.0 is the first crucial step in evaluating whether the Town's existing sources of water supply can support this level of growth.

4. EXISTING WATER SUPPLY AND WATER USE

The Town's existing water supply portfolio is comprised of groundwater, irrigation district deliveries, a CAP allotment, and treated effluent from the four operating WWTPs in the study area. Currently, the majority of the Town's water supply (an estimated 69 percent) is comprised of groundwater pumped from 18 active groundwater wells operated within the Town's service areas. Table 4-1 summarizes the contributions from each source to water use in 2007 and 2008.

Table 4-1. Contributions from Existing Sources of Water Supply for the Town of Buckeye 2007-2008 (AFY)

Source	2007		2008	
	Volume	Percent	Volume	Percent
Groundwater Pumping	4,773	68%	4,765	69%
Irrigation District Deliveries*	1,796	26%	1,423	22%
Effluent Reuse**	448	6%	712	10%
CAP Water	--	--	--	--
TOTAL	**7,017**	**100%**	**6,900**	**100%**

AFY = Acre-Feet per Year
CAP = Central Arizona Project
**Irrigation District deliveries include effluent, surface water and groundwater*
***From: Central Buckeye, Sundance, Tartesso and Sun City Festival Wastewater Treatment Plants*

Estimated per-capita water use for the *study area* is shown in Table 4-2 and was calculated based on total water use (Table 4-1) and the 2007 population estimate from ADES. Based on these inputs, the water use was calculated to be 174 gallons per capita per day (gpcd) in 2007 and 171 gpcd in 2008. The intent with this calculation is to account for all water used by the Town. As such, these results include irrigation district deliveries as well as groundwater withdrawn under Type 2 non-irrigation grandfathered rights leased and controlled by golf courses for turf irrigation.

Table 4-2. Per Capita Water Use 2007-2008

	2007	2008
Total Water Use (AFY)	7,017	6,900
Total Water Use (Gallons per Day)	6,264,785	6,160,327
Estimated Population*	35,967	35,967
Water Use (gpcd)	**174**	**171**

Note: Excludes Verrado and areas south of the Buckeye Hills
**Source: 2007 population estimate from the Arizona Department of Economic Security (40,467 residents), adjusted for the study area by the Buckeye Planning Department*
AFY = acre-feet per year
gpcd = gallons per capita per day

Conversely, ADWR does not include irrigation district deliveries or golf course deliveries in their calculations of gpcd, which were published in the Third Management Plan (ADWR, 1999). According to ADWR's methodology, water use was reported at 147 gpcd for historic Buckeye (Central Buckeye) and 163 gpcd for other areas of the Town.

4.1 Town of Buckeye Well Inventory

The existing Town water supply wells shown on Figure 2-4 include: 18 active wells that pump the Town's groundwater supply; 7 inactive wells that are connected to the system but not being used; and, 23 wells that are neither connected nor in service. The active wells provide groundwater for Central Buckeye, Sundance, Tartesso, Festival Ranch, Rancho Sunora, the Phoenix Skyline West II development, and the Buckeye municipal airport.

An inventory of all existing Town wells was performed by Town staff; pertinent well installation, construction, and capacity data are provided in Table C-1 (Appendix C). The well status provided in Appendix C also indicates whether or not the well has been conveyed to the Town by the developer. A few wells are not connected to the main distribution system, but are used locally for non-potable or potable water demands, as noted in the comments field; the connection status (i.e., direct to transmission system or to storage) for each well is also provided.

The 18 wells currently being used for the Town's municipal water supply produce from 26 to 2,000 gallons per minute (gpm), with a maximum total combined capacity of approximately 15.6 million gallons per day (17,420 AFY). Total permitted capacity, or the combined volume of groundwater that all wells are permitted to withdraw on an annual basis, is 22,317 AFY. The Town also operates one exempt well (ADWR Registry No. 55-516968) which produces a maximum of 26 gpm and supplies approximately 1.5 acre-feet of water annually to three single-family residences in the Phoenix Skyline West II development.

Overall, the Town has adequate water quantity with its existing groundwater wells, and even a surplus, however the location of the demands and the water quality limits production capacity.

Typically, a duty cycle of 75 percent is utilized for production wells, except in the summer months when many wells must be operated 24 hours a day to meet demands. When additional developments are constructed, developers are required to install and convey infrastructure, including wells, to support the new demands. As these new wells are brought on-line and existing unconnected wells are tied into the system, the Town will have the ability to more efficiently manage their groundwater supply.

Once the Town becomes a designated provider, they will have more flexibility in the pumping locations and magnitudes as pumping can be moved around at the Town's discretion. However, they will still be limited by the permitted capacity for the individual wells (Appendix C).

4.2 Town of Buckeye Groundwater Pumping

Historic groundwater pumping for the Town of Buckeye from the ADWR Wells 55 database is plotted on Chart 2 below. Groundwater withdrawals ranged from approximately 600 to 900 AFY through the 1980s and 1990s; significant increases consistent with population growth began in 2004.

Annual withdrawals have stabilized over the last three years at slightly less than 5,000 acre-feet. Reported 2007, 2008, and 2009 pumping from individual wells is summarized in Table 4-3.

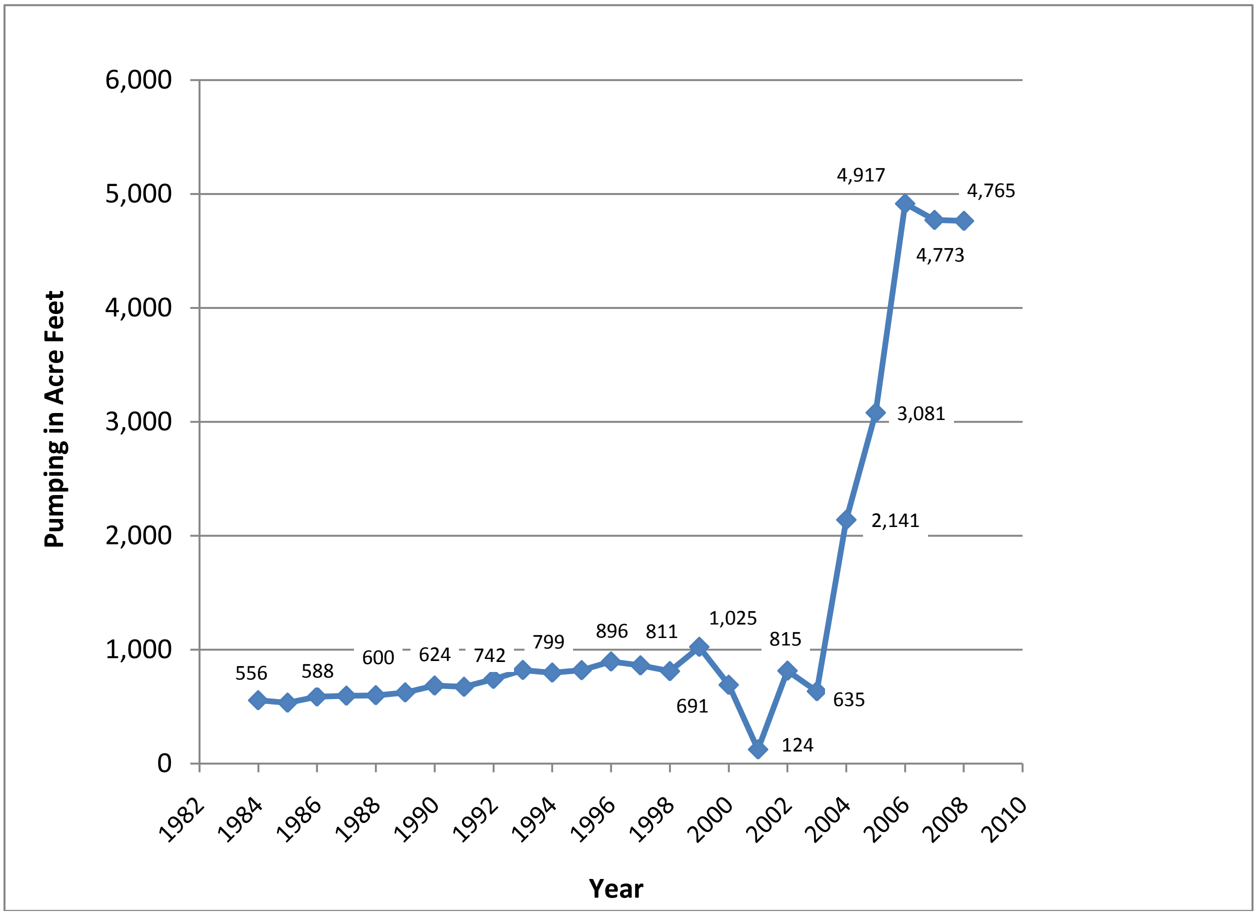


Chart 2. Town of Buckeye Groundwater Pumping 1984-2009

Table 4-3. Reported Pumping from Town of Buckeye Wells 2007-2009 (AFY)			
Well ID	**Reported Pumping 2007**	**Reported Pumping 2008**	**Reported Pumping 2009**
Church Well	170.67	105.48	64.26
Airport Well	2.68	2.40	2.04
Well 11	0.00	0.00	0.47
Well 12	484.10	311.18	357.28
Well 14	232.36	391.80	280.27
Sundance 1	797.44	582.75	566.19
Sundance 2	309.14	712.97	547.07
Sundance 3	938.17	584.78	362.55
Sundance 4	640.12	468.98	636.03
Sundance 7	0.00	154.31	292.30
Tartesso 1	217.93	382.09	285.50
Tartesso 2	599.07	489.40	327.48
Tartesso WRF	1.59	2.62	0.92
Sun City Festival 1	6.64	11.03	218.95
Sun City Festival 2	371.18	562.26	402.01
Christmas 2	1.52	1.44	1.30
Tract A	0.00	0.61	0.00
Norte Vista	0.00	0.88	0.00
TOTAL	**4,772.61**	**4,764.98**	**4,344.62**

4.2.1 Groundwater Quality

A summary of water quality for the Town wells is presented in Table 4-4. An in-depth analysis of water quality issues is outside the scope of this project, but water quality is a key aspect of planning that should be addressed in the future as a companion study to this master plan. A brief discussion of water quality challenges and an overview of groundwater quality in the Town's wells are included for completeness.

The main constituents of concern for the Town are arsenic, fluoride, nitrate, and total dissolved solids (TDS). Table 4-4 presents analytical data for these species that were compiled for the Town's DAWS application in 2008. The results are from sampling performed in 2007 and 2008, and represent the general water quality profile for each supply well.

The wells listed in Table 4-4 are grouped by geographic area to show spatial trends in water quality. Historically, TDS concentrations in the central Buckeye region (and the WSRV as well) generally exceed the secondary U.S. Environmental Protection Agency Maximum Contaminant Level (MCL) for taste and odor in drinking water of 500 milligrams per liter (mg/L). In contrast, wells that are within or in proximity to the Hassayampa River have better water quality overall. A comparison of the water quality differences by geographic region presented in Table 4-4 clearly shows these trends.

TDS concentrations in the vicinity of historically irrigated lands are generally elevated; the average TDS concentration in the waterlogged area along the Gila River corridor is approximately 3,400 mg/L (Ron Whitler, Town of Buckeye, personal communication 2010). Concentrations of TDS in the region between I-10 and the Gila River range from approximately 250 to 2,800 mg/L; higher values are indicative of close proximity to irrigated lands both in and outside of the waterlogged area.

Table 4-4. Town of Buckeye Wells Water Quality Summary 2008

Service Area Well Status	Well ID	ADWR Registration Number	Pump Capacity (gpm)	Arsenic (µg/L)	Fluoride (mg/L)	Nitrate (mg/L)	TDS (mg/L)
				MCL 10 µg/L	MCL 4.0 mg/L	MCL 10 mg/L	Secondary MCL 500 mg/L
			Sundance				
C	Sundance Well 1	55-587287	850	**18**	1.55	2.1	**611**
C	Sundance Well 2	55-588632	850	**12**	1	2.2	**830**
C	Sundance Well 3	55-578744	850	**12**	1	2.2	**830**
C	Sundance Well 4	55-598655	850	**42**	1.9	1.4	270
I	Sundance Well 5	55-595256	200	**20**	1.5	1.9	270
C	Sundance Well 7	55-206181	600	8.2	1.4	1.5	**950**
C	Sundance Well 8	55-206363	2,000	**47**	2.0	0.99	240
P	Sundance Well 9	55-206358	500	**12**	2.2	1.5	**680**
I	Ventana Ranch Well 1	55-210429	1,500	**48**	2.8	1.2	280
I	Vista Well 2	55-212487	530	**21**	1.7	2.3	370
I	Rainbow Ranch Well	55-208417	2,000	**10**	1.9	8.2	**1,800**
C	Tract A Well	55-618443	350	N/A	1.4	N/A	N/A
X	Old Tract A Well		Abandoned				
X	Hog Farm	55-600237	Abandoned				
			East of Sundance				
I	Ryland Cottonwood Well	55-206639	3,000	**69**	**6.8**	2.7	**1,700**
I	Montalbano Well	55-210699	1,600	**186**	**6.5**	1.8	**1,200**
I	SW Ranch Well	55-202889	1,200	**21**	**5.0**	5.8	**1,500**

Table 4-4. Town of Buckeye Wells Water Quality Summary 2008							
Service Area Well Status	Well ID	ADWR Registration Number	Pump Capacity (gpm)	Arsenic (µg/L)	Fluoride (mg/L)	Nitrate (mg/L)	TDS (mg/L)
				MCL 10 µg/L	MCL 4.0 mg/L	MCL 10 mg/L	Secondary MCL 500 mg/L
North Airport Road							
C	North Airport Road Well 1	55-209392	1,500	**45**	1.6	1.8	290
P	North Airport Road Well 2	55-212105	2,500	**42**	1.6	1.8	300
Southern Flank of White Tank Mountains							
E	Christmas Well 2	55-516968	35	4.9	1.4	2.2	**1,200**
X	Christmas Well 1	55-516077	Dry				
Central Buckeye near Downtown							
C	Town of Buckeye Well 9	55-602741	500	**89**	**4.2**	1.6	**1,340**
C	Town of Buckeye Well 10	55-087674	600	**29**	**4.2**	2.1	**1,330**
C	Town of Buckeye Well 11	55-529216	500	**14.9**	1.7	6.9	**2,800**
I	Reserve Well 1	55-211612	1,400	**24**	**4.0**	1.4	**1,200**
X	Old Church Well		Abandoned				
C	Church Well	55-800480	160	8.9	1	7.6	**1,200**
I	Farallon Well 1	55-202887	500	6	2.3	1.5	**950**
I	Farallon Well 2	55-206635	550	7.2	2.0	1.4	**1,000**
I	MC85 Well 1	55-211791	1,050	**74**	**4.3**	0.7	**690**
I	MC85 Well 2	55-211795	935	**62**	**4.3**	<0.02	310
Eastern Waterlogged Area							
C	Norte Vista Well	55-577731	30	6	1.65	6.51	950
West Central Buckeye – Near Hassayampa River							
P	Town of Buckeye Well 12	55-600016	1,150	4.2	0.97	7.2	230
P	Town of Buckeye Well 14	55-208811	489	6	1.1	6.4	230
C	Airport Well	55-507456	150	9	1.2	<0.2	140
I	Keck Well	55-205593	500	**20**	**6.2**	2.3	250

Table 4-4. Town of Buckeye Wells Water Quality Summary 2008

Service Area Well Status	Well ID	ADWR Registration Number	Pump Capacity (gpm)	Arsenic (µg/L)	Fluoride (mg/L)	Nitrate (mg/L)	TDS (mg/L)
				MCL 10 µg/L	MCL 4.0 mg/L	MCL 10 mg/L	Secondary MCL 500 mg/L
North of I-10 in Central Hassayampa Sub-Basin							
C	Tartesso Well 1	55-598826	1,250	5.5	2.6	1.6	360
C	Tartesso Well 2	55-201725	1,200	0.97	**4.5**	1.4	270
P	Tartesso Well 3	55-207074	2,500	9.8	2.9	2.1	280
P	Tartesso WRF Well	55-599468	200	5.3	2.2	2.4	220
I	Elianto West (EV4-1)	55-207793	1,770	7.2	**4.6**	1.3	440
I	Elianto (Lennar E-2)	55-203251	410	7.3	3.1	2	430
I	Mirielle SVOA #3	55-517029	2,500	8	1.17	1.88	170
I	Trillium Well 1	55-210423	1,450	**11**	1.8	1.5	250
I	Trillium Well 2	55-210425	1,400	4.7	0.80	2.1	210
North Hassayampa Sub-Basin							
C	Sun City Festival Well 1	55-201427	1,000	0.61	3.4	1.4	300
C	Sun City Festival Well 2	55-205078	1,000	9	1.2	1.2	470
P	Sun City Festival Well 3	55-207985	2,000	9.7	1.1	1.1	250
I	Lyle Anderson Festival Well 1	55-211434	1,600	3.8	0.80	1.6	180
Northwest of Downtown Buckeye							
I	Centex Westwind Well 1	55-210413	720	7.1	1.0	1.8	300
I	Westpark MCR #1	55-206374	300	7	1.8	5.8	**960**

C = Service Area Wells Operated by the Town
P = Pending Service Area Wells Operated by the Town
E = Exempt Wells Operated by the Town
I = Installed; not yet conveyed to the Town
X =Not in Service or Abandoned
***Bold type** indicates exceedance of MCL or secondary MCL*

gpm = gallons per minute
MCL = Maximum Contaminant Level
mg/L = milligrams per liter
ppm = parts per million or milligrams per liter
ppb = parts per billion or micrograms per liter
TDS = total dissolved solids

4.3 Irrigation District Deliveries

BWCDD and RID deliver raw water to the Town for turf irrigation. Irrigation district deliveries comprise approximately one-quarter of the Town's total water supply, and totaled approximately 1,800 acre-feet and 1,400 acre-feet in 2007 and 2008, respectively.

BWCDD water is used to irrigate land at schools, athletic fields, some parks, and a large number of individual homes south of the main canal in the older part of downtown Buckeye. RID water is used to irrigate the grounds at the Town cemetery and individual homes in the older part of Buckeye south of the RID canal, except for the 1-acre residential properties in Rancho Sunora, which are served from the Town's potable water supply. Most of the individual residences irrigated by RID water are in the Valencia Water Company (Global Water) water service area, located directly north of downtown Buckeye and south of the RID canal (Figure 2-2).

4.4 CAP Allotment

The Town has a CAP allotment that decreases each year until it reaches 25 acre-feet in 2034 and then remains at that volume until the end of the current contract period in 2054. The contract has a renewal provision, which requires the Town to submit a written request for renewal one year prior to the contract expiration date. Without designated provider status or infrastructure to divert and deliver the water, it has not been economical to utilize this allotment. Once a designated provider, the Town will have the option to store the CAP allotment and earn long-term storage credits to offset replenishment obligations, as the CAP water can be used for municipal and industrial demands as well as groundwater recharge. Table 4-5 presents the entitlement schedule for the Town's CAP allotment.

Table 4-5. Town of Buckeye CAP Entitlement

Year	Entitlement (Acre-Feet per Year)
2010	363
2011	349
2012	335
2013	321
2014	307
2015	293
2016	279
2017	265
2018	251
2019	237
2020	222
2021	208
2022	194
2023	180

Table 4-5. Town of Buckeye CAP Entitlement

Year	Entitlement (Acre-Feet per Year)
2024	166
2025	152
2026	138
2027	124
2028	110
2029	96
2030	81
2031	67
2032	53
2033	39
2034 - 2054	25

4.5 Treated Effluent

Treated effluent is a critically important component of the Town's water supply portfolio, even though at present it comprises the smallest fraction of the total water used (Table 4-1). Beneficial reuse of treated effluent is increasing as the Town identifies additional, non-potable demands that can be met with this source of supply. Details and a discussion of (1) the existing, planned, and future plans for reuse and recharge of treated effluent, and (2) the significance of this water source to the Town's future sustainability are discussed in Sections 5.0 and 6.0.

5. EXISTING EFFLUENT SUPPLY

The Town's current service areas and WWTP or WRF locations are shown on Figure 5-1. There are currently six operating WRFs within the Town MPA. Except for the ASPC-Lewis WWTP in the Gila Bend Basin, all effluent is treated to Class A+ standards and thus can be used for Class A designated uses listed in Table 5-1, as well as any designated uses for lower classes (B and C). The four WWTPs located within the study area are the focus of this section and include: Central Buckeye, Sundance, Tartesso West, and Festival Ranch WWTPs.

In 2006, the Town adopted Ordinance 86-06 requiring recharge and/or reuse of treated effluent within the Town MPA boundaries in order to "ensure the efficient use of water and wastewater resources for the benefit of the Town and its residents." Recharge and reuse of treated effluent is growing rapidly, despite limitations imposed by waterlogged conditions at the CBWWTP and the lack of infrastructure in newer areas that are in the early stages of the development cycle. In the future, this source of supply will become a cornerstone for supporting growth and a sustainable population.

Table 5-1. Designated Uses for Treated Effluent Classes A, B and C	
Class A	
Irrigation of food crops	Toilet and urinal flushing
Recreational impoundments	Fire protection systems
Residential landscape irrigation	Spray irrigation of an orchard or vineyard
School ground landscape irrigation	Commercial closed loop air conditioning systems
Open access landscape irrigation	Vehicle and equipment washing (not self serve)
Class B	
Recharge	Dust control
Surface irrigation of an orchard or vineyard	Construction water
Golf course irrigation	Milking animal pasture irrigation
Restricted access landscape irrigation	Livestock watering (dairy animals)
Landscape impoundment	Street cleaning
Concrete and cement mixing	Materials washing and sieving
Street cleaning	
Class C	
Pasture or livestock watering for non-dairy animals	Irrigation of fiber, forage, seed or other similar crops
Irrigation of sod farms	Silviculture

Source: Arizona Administrative Code R18-11-301 through 309 and Table A.

5.1 Existing Supply and Beneficial Recharge and Reuse

In the Town's Service Areas, treated effluent is recharged, reused or discharged to canals or washes. *Beneficial* reuse is defined as direct reuse or permitted recharge at a constructed facility (basins or recharge wells). Although a large portion of discharge to natural washes or streams does infiltrate and is a source of recharge to the aquifer system, this disposal option has limited value to the Town due to regulatory and permitting limitations and is not considered to be beneficial reuse. If the discharge reach is permitted as a "managed" recharge facility, the Town earns only 50 percent of the total volume recharge; when unpermitted, this type of discharge earns no storage credits that can be used later to offset replenishment obligations. The Town's goal is to attain 100 percent beneficial reuse of treated effluent; this policy would preclude unpermitted recharge facilities and eliminate discharge to natural washes or streams (either permitted or unpermitted).

Table 5-2 compares the Town's available supply with the beneficially reused volumes of treated effluent for 2007 through 2009. Approximately 25 percent of the available supply was beneficially reused or recharged in 2007. Although the total available supply increased slightly during this time period, recent efforts to more fully utilize this source of supply are evident as the percentage of beneficially reused effluent supply increased to 39 percent by 2009.

Table 5-2. Town of Buckeye Treated Effluent Supply – 2007 through 2009

Facility	2007		2008		2009	
	Available Supply (AFY)	Beneficially Reused (AFY)	Available Supply (AFY)	Beneficially Reused (AFY)	Available Supply (AFY)	Beneficially Reused (AFY)
Central Buckeye WWTP	1,157	0	1,299	0	1,237	91
Sundance WRF*	846	448	954	650	977	668
Festival Ranch WRF	31	0	94	62	131	81
Tartesso West WRF**	87	87	149	149	135	135
TOTAL	**2,121**	**535**	**2,496**	**861**	**2,480**	**975**
Percentage of Available Supply Beneficially Reused or Recharged	**25%**		**35%**		**39%**	

Note: Excludes Verrado and Gila Bend Basin regions

**Beneficial reuse at Sundance includes golf course irrigation; discharge to BWCDD canal is not included*

***Recharged at permitted facility*

AFY = acre-feet per year

5.1.1 Central Buckeye

The CBWWTP is located within the waterlogged area, directly south of downtown Buckeye on 7th Street south of Beloat (Figure 5-1). Effluent treated to A+ standards at this facility is either reused or discharged to the Arlington Canal (Figure 5-1), where it is available to downstream irrigators. Once the water enters the canal, the Town relinquishes its rights to the water. If the water is not diverted from the canal for agricultural purposes, it is discharged into Centennial Wash which, in turn empties into the Gila River just upstream of Gillespie Dam. The water may be stored behind the dam for a period, but eventually it is routed out of the sub-basin. Discharge to the canal is not considered a beneficial use.

In 2009, the treated effluent was beneficially reused to satisfy the following demands:

- Process water at the plant.
- Irrigation of the newly expanded Earl Edgar Recreational Facility located at Miller Road and Beloat, via a 12-inch water line of purple pipe (the designation for treated effluent lines).
- Fire suppression training activities held at the nearby fire department training facility.
- Dust control, street sweeping, and construction water which is accessible via a fill station constructed at the plant.

Currently, only 7 percent of the total effluent supply from the CBWWTP is beneficially reused, however the reuse options have contributed to a significant reduction in potable water use at the plant. Water billing records from the Town reflect a 44 percent reduction in potable water use from 2007 to 2009. Additionally, construction is underway to route treated effluent from the CBWWTP to Buckeye Elementary School for landscape and athletic field irrigation.

5.1.2 Sundance

Effluent treated to A+ water quality standards at the Sundance WRF is beneficially reused for irrigation at the Sundance Golf Course (Figure 5-1). In 2009, golf course irrigation utilized 68 percent of the total effluent supply. Effluent in excess of the golf course demand is routed to BWCDD's Buckeye Canal, approximately 2.5 miles away, via a 20-inch low pressure effluent pipeline. An agreement between the Town and BWCDD currently exists allowing this discharge.

5.1.3 Festival Ranch

The Festival Ranch WRF produces effluent that has been treated to A+ water quality standards. Currently, treated effluent is reused to irrigate an existing golf course within the development. Effluent in excess of the golf course demand is discharged via Wagner Wash (Figure 5-1), located adjacent to the treatment plant. Reportedly, the discharge infiltrates very quickly into the coarse streambed materials along the wash. At this time, there is no recharge permit for a managed linear recharge facility that would earn long-term storage credits for 50 percent of the WWTP discharge to Wagner Wash.

5.1.4 Tartesso West

The Tartesso West Service Area has the only permitted recharge facility owned and operated by the Town. All treated effluent from the Tartesso WWTP is recharged at this facility, located approximately 1.5 miles southwest of the development (Figure 5-1). Operations at the recharge facility began in March of 2007; reported recharge for 2007 was 87 acre-feet, increased to 149 acre-feet in 2008, and then dropped to 135 acre-feet in 2009.

The current Tartesso recharge permit is for a maximum recharge volume of 20,163 AFY, which is tied to groundwater pumping: recharge volumes cannot exceed 50 percent of Tartesso's total groundwater pumping. Recently, a permit modification was approved and the Town is presently earning long-term storage credits for the recharge.

5.2 Additional Reuse/Recharge Options – Existing Facilities

Table 5-3 is a summary of the existing and additional reuse or recharge options that are feasible in the short term (within the next 10 to 20 years) at each of the four existing facilities in the study area. The Town is actively planning to install valves, outlets, and filling stations to supply construction water and fire protection activities at all of the plants in the near future, as this has been very successful in reducing potable water demand at the CBWWTP. Although there are additional options that can be explored to increase the amount of beneficial reuse or recharge of the effluent supply, two key issues should be addressed in the short term: (1) identification of viable alternatives for beneficial recharge or reuse of the large volume of treated effluent discharged to the Arlington Canal from the CBWWTP; and, (2) obtaining recharge permits for Sundance and Festival Ranch WRF discharges into nearby canals and washes.

Table 5-3. Additional Reuse/Recharge Options for the Existing Town of Buckeye WWTPs

Facility	Recharge Options		Reuse Options				
	Permitted Recharge	In Lieu Recharge	Golf Course	Construction Water	Agriculture	Fire Protection	Turf
Central Buckeye WWTP	Yes	Yes	No	✓	Y	✓	✓
Sundance WWTP	Yes	Yes	✓	Yes	Y	Y	Y
Festival Ranch WWTP	Yes	No	✓	Yes	—	Y	Y
Tartesso West WWTP	✓	No	No	Y	—	Y	Y

✓ = Existing Reuse/Recharge

The Tartesso West WRF is a good model for the beneficial reuse of treated effluent, as the recharge basins and a recharge permit were in place from the beginning of development. As the plant expands, additional reuse options can and will be identified, but basin recharge will always be available. With this approach, the Town derives the maximum benefit from this source of supply, even during startup when the volume of treated effluent is small. At Tartesso West WRF, recharge at their constructed facility is currently, and will continue to be, the primary reuse option for treated effluent; other reuse options are secondary. This situation could be reversed for developments without access to the acreage required for a basin facility and where recharge wells may not be cost effective based on the subsurface lithology, but the point is that installation of recharge infrastructure during the early phase of development maximizes the benefits to the Town.

The disposal of treated effluent from the Festival Ranch WRF to Wagner Wash is done without the benefit of a recharge permit and is a loss of a valuable water resource. If permitted, this disposal option would, at a minimum, earn long-term storage credits equal to 50 percent of the total volume discharged. If permitted as a constructed in-stream facility, which would be more costly to construct and require additional permits, this recharge would earn the maximum number of storage credits. After accounting for losses due to evaporation, the maximum number of storage credits for a basin facility is approximately 95 percent of the total volume discharged. At the very least, the discharge should be permitted as a managed facility.

Disposal of a portion of the treated effluent produced at the Sundance plant via the Buckeye Canal is also a loss of potential water supply and financial savings for the Town. The Town has applied for a Water Storage Permit to route effluent to the Roosevelt Canal to earn storage credits under the irrigation district's existing In Lieu Recharge Permit (Groundwater Savings Facility Permit). This is discussed more fully in Section 9.0.

Finally, the large volume of treated effluent from the CBWWTP is a resource that the Town needs to exploit in the short term. The plant's location in the waterlogged area limits the options for beneficial reuse or recharge due to the shallow water table, but there are a number of alternatives to the current disposal option, as discussed below.

5.3 Alternatives for Beneficial Use of CBWWTP Effluent

The majority of the Class A+ effluent treated at the CBWWTP is discharged to the Arlington Canal (Figure 5-1) via a short segment of BWCDD canal. The total volume of treated effluent produced in 2009 was approximately 1,200 acre-feet. Of this amount, only 7 percent was beneficially reused and the remainder was discharged to the canal. The ACC runs an irrigation district directly west of the central Buckeye region near Arlington, Arizona; the canal that routes water to these lands begins well upstream of the district boundary and runs roughly parallel to the Gila River. The canal delivers return flow water from upstream irrigation, Gila River water, surface water runoff, treated effluent from the 91st Avenue WWTP (if not diverted by other users), and treated effluent from the CBWWTP to the downstream irrigation district customers. The canal ultimately routes any unused flows back into the Gila River upstream of Gillespie Dam (Figure 5-1).

The discharge of treated effluent to the Arlington Canal provides an efficient and readily available disposal option; however, its main drawback is that long-term storage credits for aquifer recharge are not received for this water supply. Long-term storage credits directly offset CAGRD replenishment costs of groundwater pumping, which will be significant once the Town becomes a designated provider (Section 2.5). Designated providers must recharge or pay the CAGRD to replenish 67 percent of their groundwater pumping. If the 1,146 acre-feet that was discharged to the canal in 2009 were to be recharged at a *managed* facility, earning long-term storage credits for 50 percent of the discharge volume, this would represent a savings of $198,258 per year in replenishment fees. If the 1,146 acre-feet that was discharged to the canal in 2009 were to be recharged at a *constructed* facility, this would represent a savings of $396,516 per year in replenishment fees. Both calculations are based on the 2010 replenishment rate of $346/acre-foot, and do not account for evaporation or projected increases in CAGRD fees (Section 6.4.4).

The Town anticipates receiving its designation status in late 2010 or early 2011, thus beneficial reuse or recharge of this treated effluent is highly desirable in order for the Town to immediately begin to offset its replenishment obligation. Disposal options at the CBWWTP, however, are limited. Due to shallow groundwater in this region, a straightforward recharge basin at the plant to earn long-term storage credits is not a viable option, as Arizona state regulations stipulate that permitted recharge facilities may not increase water levels in the waterlogged area by one foot over the 20-year recharge permit period. Recharge permits will therefore not be granted within this region; moreover, recharge within a certain distance of the waterlogged area boundary would not be feasible, except at very low volumes, as it too would cause a greater-than-one-foot rise in the waterlogged area.

Several alternatives to beneficially utilize the CBWWTP treated effluent have been identified. These alternatives are preliminary, although initial discussions have been held to discuss feasibility with potential partners/customers and the state regulatory agency. The alternatives are briefly summarized in Table 5-4.

Section 9.0 presents recharge/reuse guidelines and a schematic of conceptual reuse piping. Alternatives for the CBWWTP effluent supply that are reflected in the reuse pipeline network include: piping the water north to the RID canal for use by irrigators, or subsequent routing to the Tartesso recharge facility, and piping the water north of I-10 to a new recharge facility to be built by the Town.

Table 5-4. Alternative Uses for Central Buckeye WWTP Effluent

Description	Partners or Customers	Benefits	Considerations
Identify additional uses for treated effluent in the vicinity of the plant	Buckeye Residents and Businesses	Reductions in pumping, indirectly reducing replenishment costs	Additional infrastructure to deliver water
Pipe water north and discharge to RID canal for use by irrigators ***or*** Pipe water north and discharge to RID canal, wheel it to Johnson Road, divert it into a pipeline that routes it north to the Tartesso Recharge Facility	Roosevelt Irrigation District Roosevelt Irrigation District	Reductions in irrigation pumping qualifies as in lieu recharge for Long-Term Storage Credits Long-Term Storage Credits	In lieu recharge permit, piping, negotiations and contract with RID Piping to RID canal, piping north to recharge facility; negotiations and contract with RID; modification to Tartesso recharge permit
Pipe water north to a new recharge facility	Potentially, Maricopa County Flood Control District	Long-Term Storage Credits; autonomy in facility management; long-term infrastructure	Siting study, land costs, recharge permit, infrastructure (piping and basins/wells)

Table 5-4. Alternative Uses for Central Buckeye WWTP Effluent

Description	Partners or Customers	Benefits	Considerations
Wheel water via the Gila River into the Gila Bend Basin to a new diversion south of Gillespie Dam	TBD	Revenue from sale of water	Retaining control of the effluent; use in the planning area versus the service area; losses through evaporation and infiltration; Sub-basins boundary issues; treated; effluent quality degradation (mixing with Gila River water); negotiations and contract
Wheel water via the Gila River into the Gila Bend Basin to a new recharge facility ***or*** Wheel water via the Gila River into the Gila Bend Basin to a new customer	TBD	Long-Term Storage Credits in Gila Bend Basin – can be sold locally or water can be recovered and piped back into Central Buckeye Revenue from sale of water; customer covers majority of infrastructure costs	Retaining control of the effluent; use in the planning area versus the service area; losses through evaporation and infiltration; Sub-basins boundary issues; treated; diversion, recharge permit, recharge basins or wells; very high cost of infrastructure if water recovered and brought back to Central Buckeye Negotiations and contract; must evaluate water quality impacts from mixing with Gila River water
Pipe water north to the Palo Verde Generating Station pipeline	Palo Verde Generating Station	Revenue from sale of water; potential customer for additional water as plant expands	Piping and connectivity, negotiations and contract

6. SUSTAINABILITY ASSESSMENT

This section discusses the development of sustainability criteria for the Town's groundwater resources and the application of these criteria to an assessment of long-term groundwater supplies. The *Lower Hassayampa Sub-Basin Hydrologic Study and Computer Model* (Brown and Caldwell, 2006) was used to perform the sustainability assessment. The model domain includes the vast majority of Buckeye's MPA and neighboring groundwater users in the Hassayampa and WSRV Sub-Basins, and excludes only the Verrado region and locations south of the Buckeye Hills. The Hassayampa model is well suited to an assessment of Buckeye's groundwater resources as it simulates the portion of the MPA that is served by Buckeye and anticipated to undergo the most growth over the next 20 years.

The sustainability assessment methodology consists of the following components:

- Water resources planning constraints, which define the Town's water portfolio, hydrologic conditions, and planning timelines;
- Sustainability criteria, which provide a means to quantitatively evaluate results of the assessment;
- Groundwater model, which provides a tool to assess future impacts of pumping and water policies; and
- Predictive simulation assumptions, which describe future potential water demands, recharge and water management practices, and which can be adjusted during the assessment to find sustainable water management solutions.

The sustainability criteria developed for the Town (Table 6-1) comprise a particularly key element in estimating the long-term sustainability of groundwater resources. The predictive simulation assumptions regarding future hydrologic conditions are equally important in the predictive simulations, and in some cases, more influential on modeling results and follow-on sustainability analyses. These criteria and assumptions are summarized in Table 6-1, and discussed in greater detail in the following sections.

Table 6-1. Sustainability Constraints and Criteria for the Town of Buckeye

Sustainability Constraints	Description
Future Conditions / Simulation Time	The predictive simulation was run for 150 years into the future.
Sources of Water	Groundwater wells, augmented by effluent recharge/reuse and other artificial recharge sources (CAGRD replenishment).
Effluent as a Source of Supply	The effluent supply was estimated to be 35 percent of total groundwater pumping. All groundwater pumping for developments and water providers in the model domain was cut by 35 percent to account for this supply (except Tartesso).
Artificial Recharge – Tartesso	The effluent supply for the Tartesso properties was assumed to be 35% of total groundwater pumping; this effluent was recharged.

Table 6-1. Sustainability Constraints and Criteria for the Town of Buckeye	
Sustainability Constraints	**Description**
Artificial Recharge – CAGRD	Buckeye's replenishment obligation was recharged at the two existing CAGRD facilities in the region. The replenishment obligation of 67 percent was reduced by 35 percent to account for effluent supplies that are recharged or reused locally.
Regulatory Depth to Water	Regulatory criterion: groundwater pumping shall not cause future water levels to decline to or below 1,000 feet below land surface.
Thickness of Aquifer	Hydrogeologic criterion: At the end of the predictive simulation, viable well locations are defined as those with a minimum thickness of aquifer of 150 feet.
Aquifer Depletion	Hydrogeologic criterion: "Dry cells" within the groundwater model will be considered to be unsustainable zones of groundwater/aquifer depletion.
Depth to Water	Hydrogeologic criterion: Groundwater pumping shall not cause future water levels to decline to or below 800 feet below land surface.
Cost of Lifting Water	Cost criterion: used to refine the depth-to-water criterion and estimate future water supply power costs.
Cost of CAGRD Replenishment Cost	Cost criterion: used to better understand the cost of CAGRD recharge and benefits of localized effluent recharge and reuse.

6.1 Sustainability Criteria

Criteria to assess the sustainability of long-term groundwater supplies were developed in an iterative process in conjunction with the Town's Water Resources Department. The criteria are applied to, and used for, interpreting and evaluating the results of the predictive numerical model simulations. These criteria provide a framework for quantification of the volume of sustainable groundwater pumping that can occur in the future. The sustainability criteria were designed specifically for Buckeye, based on the physical characteristics of the aquifer system, nearby water providers and water users, and the Town's plans for growth. Three general classifications of criteria were utilized in the sustainability assessment: 1) regulatory limitations; 2) hydrogeologic considerations; and 3) cost of operations.

6.1.1 Regulatory Limitations

Regulatory and permitting constraints on AWS applications utilized by ADWR were evaluated for use in the Buckeye sustainability assessment. AWS regulations stipulate that a water provider cannot draw groundwater levels down to depths greater than or equal to 1,000 feet below land surface (bls) over a 100-year period. Although this standard is used to determine the regulatory, physical availability of groundwater supplies, it allows for substantial aquifer depletion. Should predictive model results pass this sustainability criterion, meaning that depths to water remain less than 1,000 feet, it does not ensure that water can be continuously produced from a well field in sufficient quantities. Likewise this methodology ignores the declining production potential of an aquifer as it desaturates and larger fractions of water are produced from deeper, potentially less productive units. In the Buckeye region, and in fact in many basin-fill aquifer systems, the potential for water quality degradation generally increases with depth. This may not limit the quantity of water, but could result in prohibitive treatment costs prior to serving the water.

For ADWR permitting activities, the above regulatory criteria are appropriate and should be fully considered as a first approximation of the available groundwater supply. However, given the hydrogeologic data, limitations of the aquifer system, and the response of the aquifer system to the level of pumping anticipated in the Buckeye MPA, the application of these criteria alone to predictive model results could overestimate sustainable withdrawals from the aquifer system in the future. It was critical, therefore, to expand upon the 100-year timeline and the 1,000-foot limit on drawdown for the estimation of long-term, sustainable pumping rates.

6.1.2 Aquifer Limitations

Sustainability criteria based upon hydrogeologic information address the physical limitations of the aquifer to produce a suitable quantity of groundwater as water levels decline in the future. The original Hassayampa model simulations (Brown and Caldwell, 2006) and the Buckeye DAWS simulations (Brown and Caldwell, 2008) all resulted in significant drawdown and dewatering in two key areas: the Neck region between the Belmont and White Tank Mountains, and the portion of the basin immediately northwest of the White Tank Mountains. The stresses on the aquifer system in the Neck are substantial, and are predicted to cause a reversal of the southward direction of flow in the future. The lateral extent of the viable aquifer in the Neck region shrinks to encompass only the deepest portions of the aquifer, as areas close to the mountain fronts dewater. Because the total depth of the aquifer in the Neck is generally not much greater than the 1,000-foot drawdown criterion, there are concerns that an inadequate thickness of saturated aquifer will remain after 100 years. In other words, 100 years of pumping may be sustainable according to the regulations, but a viable aquifer that can support future pumping may not exist in reality. *A new criterion to require that a minimum thickness of aquifer remains at the end of the simulation was therefore incorporated into the sustainability assessment; the minimum thickness was set at 150 feet.*

In the model simulation built to support the Buckeye DAWS application, assumptions regarding how quickly growth will occur were revised, and the aggressive ramp-up of groundwater pumping over time was scaled back considerably. This, of course, significantly reduced the total volume of water pumped during the 100-year simulation. These assumptions were applied to the sustainability modeling (Section 6.3) and are considered to be a more realistic representation of growth. However, because the growth curve is now more conservative, final buildout for many developments does not occur until 2065 (versus approximately 2040); thus, the maximum stress on the aquifer is simulated for only 43 years (2108 minus 2065). This considerably lessens the cumulative impact of pumping, although there is still a large imbalance between pumping and recharge in the basin-wide water budget.

The imbalance between pumping and recharge in the original Hassayampa model predictive runs caused some of the wells to cease pumping after approximately 35 years due to aquifer dewatering. Thus, there was a valid concern that the Sustainability Simulation could reflect favorable conditions for 100 years, only to have the imbalance in the system cause an unacceptable loss of simulated pumping wells shortly thereafter. In fact, the cumulative groundwater pumping trend in the Sustainability Simulation showed signs of pumping loss due to aquifer dewatering toward the end of the 100-year simulation. *To more adequately assess the long-term viability of the groundwater supply, the Sustainability Simulation was run for 150 years.* This criterion is also in keeping with the spirit of the AWS regulations, as the maximum aquifer stress would be simulated for almost 100 years.

It is important to note that this will not be a problem that surfaces 100+ years from now. Once the Town becomes a Designated Provider, their status will be re-evaluated every 10 years, which in turn pushes the 100-year simulation out by 10 years. With this sliding scale, and the conservative assumptions required for evaluating aquifer impacts for AWS purposes, the Town runs the risk of being required to scale back plans for growth at some time in the near future. Given this regulatory setting, the Town's preference is to follow a pro-active approach and plan now for a realistic, long-term sustainable groundwater supply.

6.1.3 Cost of Operations

The depth to water requirement for the AWS regulations was rigorously studied during the sustainability assessment with respect to its relevance for the Hassayampa Sub-Basin. The 1,000-foot regulatory limit is considered to represent an extreme situation, and is undesirable primarily due to the high energy cost of lifting water from this depth. Because the stresses on the aquifer in the Buckeye region draw down the aquifer significantly, the costs of lifting water to the surface will increase in the future throughout the Town's MPA, with the exception of the waterlogged area adjacent to the Gila River.

To evaluate a more stringent depth criterion than the regulatory limit of 1,000 feet, the first step was to define the sustainability threshold for the Neck area. Because it is the region most sensitive to pumping stresses, the depth-to-water criterion could not be set to an unrealistic value that would preclude installation of a viable, long-term well field in the Neck. Depths from 600 to 900 feet were evaluated with respect to the areal extent of the aquifer in the Neck. The sustainability threshold was found to be a depth of approximately 600 feet (Figure 6-1); thus it was decided that the selected depth-to-water sustainability criterion should be greater than 600 feet.

Additional analyses were performed to calculate the cost of lifting water to the surface from a range of depths. Currently, the depth to water in Wells 12 and 14 is approximately 100 feet. The annual cost to lift water from this depth at a pumping rate of 500 gpm is $13,273, as shown on Chart 3, below. The annual cost to lift water from 1,000 feet bls is $132,727, an order of magnitude increase. In central Buckeye, the depth to water is not anticipated to increase substantially in the future, largely due to the waterlogged conditions and the length of time that it would take to radically alter the hydrologic status quo. However, in the Neck region and northernmost portions of the Buckeye MPA, lift costs will increase substantially as more wells are installed and future drawdown increases. Table 6-2 presents the calculated costs of lift for Buckeye's existing and future wells at 25-year intervals based on the DAWS simulation. (Compared to the Sustainability Simulation, these costs are overestimated because the DAWS simulation did not include the benefits of CAGRD replenishment.) Buildout occurs in approximately 65 years, thus total pumping is constant after that time. The $2,000,000 increase in lift costs between the last two periods is therefore due solely to increased depths to water associated with depletion of groundwater. *After considering both the depth limitations and the operational costs, the depth to water criterion for the Sustainability Simulation was selected to be 800 feet.*

Table 6-2. Cost of Lift for Town of Buckeye Wells based on the DAWS Simulation

Timeline	Total Pumping (AFY)	Cost of Lift in Current Dollars*	Average Lift Cost per Acre-Foot
25 years	70,462	$3,199,586	$45
50 years	110,266	$7,104,846	$64
75 years	114,561	$9,711,682	$85
100 years	114,561	$11,801,459	$103

AFY =Acre-Feet per Year
DAWS =Designation of Assured Water Supply
**Based on a power rate of 10 cents per kilowatt-hour.*

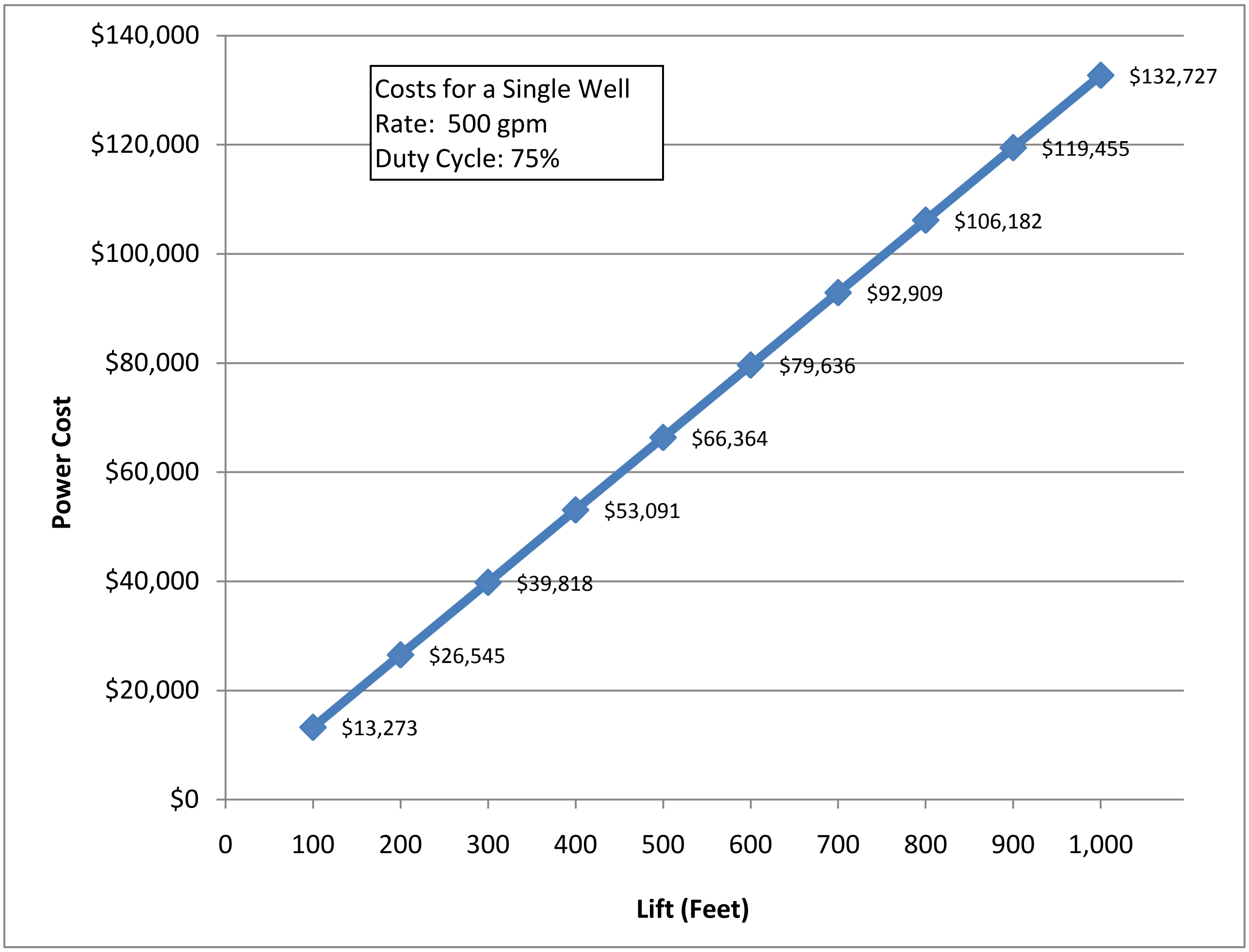


Chart 3. Annual Power Cost of Lifting Water in a Well

6.2 Modeling Assumptions

The Hassayampa model was used to assess aquifer conditions on a regional scale and evaluate the impacts of groundwater pumping in those portions of the Buckeye MPA located within the model domain (Figure 6-1). The Hassayampa model was built in MODFLOW 2000 (Harbaugh et al., 2000) and calibrated to 2003/2004 water levels. Subsequent updates were performed in June 2007 and November 2008; the 2008 revisions were in support of an analysis of pumping impacts for the Town's DAWS application. The DAWS simulation was used as the basis for the sustainability assessment with updates, revisions, and assumptions that were consistent with the Town's philosophy of sustainable growth and development.

6.2.1 Hassayampa Model Updates and Usage Assumptions

The revisions and model usage assumptions listed below relate to either (1) updates in the timeline, pumping files, and natural recharge inputs, or (2) documented inputs from the original model that were not revised for the sustainability assessment (e.g., boundary conditions).

- The model timeline begins in 2004 and was expanded through 2158 for a total of 155 years represented by stress periods 1 through 38. The 150-year predictive timeline begins in 2009 and extends through 2158 (stress periods 6 through 38).
- Actual reported pumping is reflected for 2004, 2005, and 2006 (2007 data was not yet available).
- Reported pumping for Town of Buckeye wells is reflected for 2007 and 2008. For all other wells, actual reported pumping for 2006 is held constant through 2008.
- As with all previous Hassayampa model predictive simulations, the majority of groundwater pumping was shifted to Model Layer 3 to accommodate simulated drawdown.
- Four of the Town's wells are located just outside of the active model area boundary to the southeast: Ryland Cottonwood (206639), Montalbano (210699), SW Ranch (202889), and Norte Vista (577731). As these four wells are still within the groundwater basin, they were moved to locations just inside the model boundary so that their pumping demand would be included in the simulation.
- Lag times associated with irrigated lands within the Hassayampa model domain remain, as previously documented. Lag times are currently incorporated into the Hassayampa model predictive simulations to account for infiltration through the vadose zone in the vicinity of irrigated lands.
- No changes to boundary conditions were made. The Hassayampa model boundaries include natural boundaries (crystalline bedrock), as well as boundaries that simulate connections with the adjacent WSRV Sub-Basin. Connections to the WSRV are located at the northeast Hassayampa model boundary (near Surprise) and the southeast model boundary (near Buckeye), and were assigned and parameterized based on output from the Salt River Valley (SRV) model. The fluxes at these boundaries change in response to groundwater pumping within the WSRV. Accordingly, the boundary conditions were designed to gradually reduce the amount of underflow into the Hassayampa Sub-Basin in the southeast, and reduce the amount of underflow out of the Hassayampa Sub-Basin in the northeast, consistent with projected increases in WSRV groundwater demand.

- No revisions to Gila River stream leakage or BWCDD canal leakage were made. Assumptions in the model with respect to stream and canal leakage are consistent with the original 2006 model.
- No revisions to natural recharge within the model area were made. Model assumptions with respect to natural recharge are consistent with the original 2006 model.

6.2.2 Groundwater Pumping

Groundwater pumping during the predictive timeline reflects a ramp-up of withdrawals for developments and water providers with approved Analyses, Certificates, or Designations of AWS. In addition, all groundwater rights issued in the region and pumping rights associated with entities that pre-date the AWS regulations are reflected in the model, including: industrial rights, Grandfathered Irrigation Rights (GFR), Type 1 and Type 2 non-irrigation GFRs, agricultural pumping, and pumping for wildcat lots.

The ramp-up of pumping for the Sustainability Simulation was designed to account for the recent downturn in building and development in the region, which is expected to result in very slow growth rates through 2011 and 2012. The ramp-up of growth and associated water demand in the original Hassayampa model was based on schedules from individual AWS applications for each development; the pumping ramp-up was very steep and the entire region was assumed to be built out by 2040. These schedules were revised to reflect less aggressive growth patterns that are more realistic, given current growth conditions. First, the start time for pumping was moved to 2011 or 2012 for any developments that had not yet reached the wet water stage. Second, the steep pumping ramp-up curve was flattened, essentially extending the buildout timeline. These changes were applied to all developments within the model area, including areas served by the Town of Buckeye MPA, the City of Surprise, and Global Water (and their subsidiaries). The new buildout year for the region after these adjustments was 2065.

The pumping files and ramp-up schedule used for the Sustainability Simulations is consistent with the assumptions used in the DAWS application submitted to ADWR in December 2008. As this application is still under review by ADWR, these data represent the best information available at this time.

Groundwater pumping was also adjusted downward to account for projected effluent supplies, an assumption that was revised from the DAWS simulation assumptions based on actual data from the Town and other water providers.

6.2.3 Effluent Reuse

Assumptions regarding effluent reuse were incorporated into the Sustainability Simulation for virtually all of the developments within the active model area, with the exception of wildcat lots, small municipal providers, dry lots, Tartesso (effluent is recharged, Section 5.1.4), and developments with a very small total demand. Research on the amount of effluent that returns to the wastewater system and becomes available for reuse or recharge was performed in support of the original Hassayampa model development (Brown and Caldwell, 2006); the results of the study indicated that effluent volumes range from 19 to 53 percent of total water use. The Town data are very limited and multi-year estimates of the effluent supply as a percentage of total water use or total groundwater pumping are not feasible. For 2008, however, it was calculated that the effluent supply was approximately 55 percent of the total water use (Town of Buckeye Water Conservation Plan, June 2009). For a long-term planning estimate, the Town elected to assume that 35 percent of total water use would become effluent available for recharge or reuse. This relatively conservative estimate is consistent with the reported return rate for the City of Phoenix.

Effluent reuse for individual developments and providers was assumed to begin in 2010, 2011, or 2012, depending upon the current stage of development, ramping up from 4 percent in the first year to the maximum rate of 35 percent of total pumping in the 8th year and all subsequent years. This effluent supply was simulated as a direct reduction in groundwater pumping. Reducing groundwater pumping to account for effluent reuse or recharge implies that the reuse/recharge will occur locally, in or near the development footprint.

6.2.4 Artificial Recharge

Three of the permitted recharge facilities are located within the model area and were therefore included in the Sustainability Simulation: Tartesso WRF, Tonopah Desert Recharge Facility, and Hieroglyphic Mountains Recharge Facility.

Because the Tartesso facility is currently recharging treated effluent under an existing permit, the Tartesso properties were assumed to recharge instead of reuse. Pumping was not reduced, as it was for all other developments and water providers, and recharge at the existing facility was a direct modeling input. Actual reported values were simulated through 2008, at which time recharge volumes were calculated as a percentage of the projected pumping. The percentage of pumping that was recharged each year slowly ramped up to a maximum of 35 percent to maintain consistency with assumptions regarding effluent reuse.

The Hieroglyphic Mountains and Tonopah Desert Recharge Facilities are owned and operated by CAGRD. Recharge simulated at these facilities was assumed to be replenishment water only. Stored water that would later be recovered was not simulated as recharge. In the Sustainability Simulation, replenishment at the two facilities was limited to Buckeye's replenishment obligation, which will be 67 percent of total groundwater pumping once they are a Designated Provider. However, because 35 percent of their total pumping is assumed to be recharged (or reused), the replenishment obligation that would be met by CAGRD recharge was dropped to 32 percent (67 percent - 35 percent = 32 percent). The majority of this replenishment was recharged at Tonopah Desert, and the remainder at the Hieroglyphic Mountains Facility. Table 6-3 summarizes the assumptions regarding replenishment recharge at the CAGRD facilities in the Sustainability Simulation.

Table 6-3. Summary of Replenishment Recharge in the Sustainability Simulation by Buildout (Acre-Feet/Year)

Total Buckeye Pumping	**150,738 AFY**
Replenishment Obligation (67% of Total Pumping)	100,995 AFY
Effluent Recharge/Reuse (35% of Total Pumping)	52,758 AFY*
Adjusted Replenishment Obligation (67%-35%)	**48,236 AFY**
Replenishment Obligation Recharged at Tonopah Desert Facility	32,800 AFY
Replenishment Obligation Recharged at Hieroglyphic Mountains Facility	15,436 AFY

**This volume simulated as a direct reduction in pumping or as local recharge (Tartesso)*

6.2.5 Retirement of Irrigated Lands

The retirement of irrigated lands, an assumption required by ADWR in the original 2006 Hassayampa model simulations, was revised for the Sustainability Simulation. Previously, it was assumed that irrigated lands along the Gila River corridor would convert from agricultural to urbanized land uses; the conversion timeline was based on MAG population projections through 2030, and took into account all contracts and decreed/appropriative surface water rights. (No conversion was assumed for irrigated lands in Tonopah, Centennial Wash, or Arlington because the population projections did not cover these areas.) A small portion of the irrigation pumping was converted to municipal pumping. Despite this, the overall result was a substantial reduction in pumping demand: RID pumping was eliminated completely, and BWCDD pumping was significantly reduced and then zeroed out by 2020 (Brown and Caldwell, 2006).

With the recent reduction in development activities, it is uncertain when the agricultural areas will transition to residential development, and even with a change in land use the possibility exists that residential areas may receive landscape irrigation water from the irrigation districts. One of the Town's goals is to maximize the use of irrigation district water for landscape irrigation, construction water, and dust control, where practical. Additionally, the irrigation districts are cognizant of trends that will reduce or eliminate the lands that they serve, and are exploring other alternatives.

The assumption to convert the lands without comparable pumping for alternative purposes was therefore removed from the Sustainability Simulations, essentially maintaining present-day irrigation practices. Actual reported pumping by RID and BWCDD was updated through 2006. Beginning in 2007 and continuing for all subsequent years, an average pumping rate based on the last 5 years of reported pumping was calculated and simulated for each of the irrigation district wells. Recharge associated with the RID and BWCDD irrigated lands previously classified as retired was also added back into the Sustainability Simulation.

6.3 Sustainability Model Runs

Four simulations were run to identify the amount of groundwater pumping that passes the specified sustainability criteria and assess the impacts of regional scale recharge at the CAGRD facilities. Assumptions used in each of the simulations are summarized in Table 6-4. The Buckeye Sustainability Simulations results were used to quantify the amount of groundwater that can be sustainably withdrawn in the portion of the Buckeye MPA that is included in the model domain. The other simulations were run for comparison purposes to more clearly understand the benefits of recharge.

Table 6-4. Replenishment Assumptions in the Modeling Scenarios

Scenario	Predictive Simulation Timeline	Effluent as a Percent of Total Groundwater Pumping	CAGRD Replenishment Assumptions (Acre-Feet/Year by Buildout)
Buckeye Sustainability Simulation	150 years	35%	Buckeye's replenishment obligation recharged at the CAGRD Facilities: total = 48,236 AFY
No Replenishment	150 years	35%	No replenishment assumed at the CAGRD Facilities

Table 6-4. Replenishment Assumptions in the Modeling Scenarios			
Scenario	**Predictive Simulation Timeline**	**Effluent as a Percent of Total Groundwater Pumping**	**CAGRD Replenishment Assumptions (Acre-Feet/Year by Buildout)**
Low Replenishment	150 years	35%	A portion of Buckeye's replenishment obligation recharged at the CAGRD Facilities: total = 39,458 AFY
High Replenishment	150 years	35%	Buckeye's replenishment obligation plus a portion of other water users' obligations are recharged at the CAGRD Facilities: total = 65,868 AFY

6.4 Sustainability Modeling Results

Results of the model runs performed for sustainability are presented on Figures 6-3 through 6-6. A comparison of the sustainable water supply that resulted from each of the four simulations is provided in Table 6-5. Non-sustainable pumping volumes reported in Table 6-5 include: wells that went dry during the simulation, wells in locations that had less than 150 feet of saturated thickness at the end of the simulation, and wells that had a depth to water equal to or below 800 feet.

Table 6-5. The Impacts of Regional Recharge on Sustainability (Acre-Feet per Year)				
	No Replenishment	**Low Replenishment**	**Sustainability Simulation**	**High Replenishment**
CAGRD Replenishment	0	39,458	48,236	65,868
Total Water Supply*	203,496	203,496	203,496	203,496
Non-Sustainable Pumping	52,383	43,647	42,628	37,705
Sustainable Water Supply**	132,779	144,573	145,948	152,594
Percent Sustainable	65%	71%	72%	75%
Ratio of Replenishment Water that Increases Buckeye's Sustainable Water Supply	--	3.3 to 1 AFY	3.7 to 1 AFY	3.3 to 1 AFY

Note: all volumes based on predicted 2158 recharge, pumping and depths to water.
**Includes: Groundwater (150,078 AFY) plus Effluent (52,758 AFY) = 203,496.*
***Sustainable Water Supply = Total Water Supply – (Non-Sustainable Pumping x 1.35)*

6.4.1 Predicted Water Level Contours in 2158

Figure 6-3 is a water level contour map depicting the predicted flow system in 2158 for the Sustainability Simulation. The cones of depression indicate that the largest net groundwater withdrawals are located in the Neck region and in the southwest near the power plants. When the pattern of predicted water level contours is compared to present-day water level contours

(Figure 2-7), it can be seen that the southward direction of flow is reversed by 2158 in the southern portion of the model, and groundwater flows northward to the central cone of depression in the Neck area.

Large portions of the shallow aquifer system, represented by Layers 1 and 2 of the model, desaturate by 2158 in the predictive simulations. In Layer 1, the region along the Gila River corridor remains saturated, as well as areas within the immediate vicinity of the CAGRD recharge facilities; similar regions in Layer 2 remain saturated. All other regions in Layers 1 and 2 are dry by 2158. Although portions of Layer 3 also desaturate, particularly along the basin margins, this model layer remains saturated and provides the greatest potential for long-term aquifer production. All figures showing water levels and depth to water in 2158 represent model Layer 3.

6.4.2 Predicted Depth to Water in 2158

Figure 6-4 is the model-simulated depth to water in 2158 for the Sustainability Simulation. Depth to water was calculated using simulated drawdown, one of the main outputs from MODFLOW. The model-simulated drawdown in 2158 was subtracted from the observed 2006-2007 water levels shown on Figure 2-7. This result was then subtracted from the ground surface elevation to calculate the depth to water below land surface in 2158.

Model cells with a depth to water greater than or equal to the sustainability criterion of 800 feet bls are shown in shades of yellow, orange, and red; cells with a depth to water less than 800 feet bls are shown in shades of green. Cells that are visible on the margins of the basin but have no color flood are cells that dried out during the simulation. (Note that a few cells south of the White Tank Mountains, in the vicinity of the Gila River and in the south central model area, are not color flooded because the wells in this area are not pumping from Layer 3, they are pumping from Layers 1 and 2. These cells do not dry out.)

Wells posted on Figure 6-4 are the existing and future Town wells. Any well located in regions that experience drawdown to depths greater than or equal to 800 feet (wells located in yellow, orange, or red cells) are not considered sustainable for the 150-year simulation. In the Sustainability Simulation, 72 percent of Buckeye's total water supply was sustainable for 150 years (Table 6-5); a total of 42,628 AFY of Buckeye's pumping was located in non-viable areas. This is not to say that the aquifer zones that become dewatered or that are drawn down below 800 feet will not support any pumping at all; indeed, these areas would likely support at least one generation of wells, possibly two or three, depending upon the life expectancy of a well, which can range from 20 to 60 years. At some point, however, it is likely that replacement wells would have to be located elsewhere.

6.4.3 Local versus Regional Recharge

Assuming that effluent reuse/recharge will total 35 percent of future groundwater pumping implies both local reuse and local recharge throughout the region. This assumption was applied to all developments and water providers within the model domain, not just to Buckeye's MPA.

For comparison purposes, depth-to-water maps for the No Replenishment and High Replenishment Simulations are provided on Figures 6-5 and 6-6, respectively. Without any CAGRD replenishment, the impacts of groundwater pumping on the Neck and the region directly north/northwest of the White Tank Mountains are dramatic: only isolated wells are sustainable in the Neck region, and none of the Town's future wells directly north of the White Tanks are sustainable. Regional-scale CAGRD replenishment improves the results, however there are diminishing returns associated with this regional scale recharge due to its distance from Buckeye's well fields. Table 6-5 presents a summary that shows the increase in Buckeye's sustainable water supply as a function of CAGRD replenishment. In this table, the sustainable water supply takes into account any non-sustainable pumping as well as the corresponding effluent supply.

The data presented in Table 6-5 is a very simplistic analysis of what is, in reality, a complex three dimensional (3-D) problem; however there is some value in the analysis as it demonstrates that there is a limit to the efficacy of recharge at the regional facilities with respect to Buckeye's sustainable water supply. Comparing the ratio of replenished water to Buckeye's sustainable water supply for each of the simulations, it can be seen that more than 3 acre-feet must be replenished at the regional facilities to result in a 1 acre-foot increase in sustainable supply. This difference is due to the delayed migration of recharged water and associated pressure response through the regional aquifer system.

From a comparison of the depth-to-water maps (Figures 6-4 through 6-6), it is clear that increases in replenishment volumes *most directly* benefit the City of Surprise and the Tonopah region. CAGRD recharge is crucial in supporting water levels throughout the sub-basin, and there is great value to Buckeye; however, due to the distal location of the recharge facilities, its effect on the Town's water supply is more subdued.

6.4.4 CAGRD Recharge Cost Assessment

Projected groundwater pumping for the Town in 2011 is 11,065 acre-feet, based on the DAWS application. CAGRD fees in 2011 will be $1,267,606, if only 32 percent of the total pumping will need to be replenished. Because the Town will not be offsetting the replenishment obligation with significant recharge/reuse by 2011, the fees will likely be closer to $2,654,051. The sooner that recharge/reuse facilities are put into place, the more savings the Town will realize in replenishment costs, particularly since the replenishment fees will increase by almost a factor of three over the next two decades (Table 6-6) as costs for power are passed on to CAGRD enrollees.

Table 6-6. Projected Replenishment Fees 2009-2030 (Dollars per Acre-Foot)

2009	$318
2010	$346
2011	$358
2012	$367
2013	$376
2014	$395
2015	$415
2016	$435
2017	$457
2018	$480
2019	$504
2020	$529
2021	$556
2022	$583

Table 6-6. Projected Replenishment Fees 2009-2030 (Dollars per Acre-Foot)	
2023	$612
2024	$643
2025	$675
2026	$709
2027	$744
2028	$782
2029	$821
2030	$862
Source: CAGRD Add Water Conferences, 2009	

By buildout, using all of the assumptions included in the Sustainability Simulation, the Town's CAGRD fees will be $41,579,432 annually; which is a best-case estimate as it assumes no increase in fees beyond the 2030 projection of $862/acre-foot and more importantly, assumes that a significant savings will be realized by local recharge/reuse of effluent. If no localized recharge/reuse of effluent was planned, and the decision was made to rely solely on CAGRD to fulfill replenishment obligations, CAGRD fees by buildout would total $87,057,225 annually (Table 6-7).

The assumption regarding recharge/reuse of effluent at 35 percent of total groundwater pumping is a key element to the Town's water resources strategy. Localized recharge/reuse is a 1-to-1 benefit from the water budget perspective. Recharge/reuse of treated effluent will also directly offset or reduce pumping stresses in areas where it is most needed. Direct reuse is most efficient in terms of the aquifer system, as it has the immediate effect of reducing groundwater pumping. However, if the effluent supply is used for an additional golf course or landscaped park that was not originally included in the water supply approved by the state, this usage would not be reducing groundwater pumping in the Sustainability Simulation, but would constitute a new demand. This is an important distinction which will likely be alleviated to a certain extent when the effluent supply can be calculated from actual long-term data. A return of greater than 35 percent would provide a surplus supply for some of these new demands.

Effluent reuse will be limited, particularly during the winter season when demands will be low. When there is a surplus, recharge of effluent supplies will be necessary. The importance of building localized recharge facilities cannot be over-stressed. Effluent discharge to a wash or dry riverbed is an efficient disposal technique and in a physical sense, it replenishes the aquifer system so is beneficially used. However, without a recharge permit for a constructed facility, the loss of long-term storage credits will result in a wasted resource, as the Town would have to replenish a like amount, or pay the CAGRD to replenish a like amount. Even with a recharge permit for a managed (natural wash or riverbed) facility, the long-term storage credits earned for effluent discharged to a wash is only 50 percent of the volume discharged. Again, the recharge benefits the aquifer system, but the monetary loss is significant and becomes more costly as replenishment fees go up.

Table 6-7. Groundwater Replenishment Cost Comparison for Town of Buckeye						
Time Period	Effluent Recharge/Reuse of 35% Satisfies a Portion of Replenishment Requirements			All Replenishment Requirements are Met through Recharge by CAGRD		
	Groundwater Pumping	Replenishment of 32%	Total Cost	Groundwater Pumping	Replenishment of 67%	Total Cost
2011	11,065	3,541	$ 1,267,606	11,065	7,414	$2,654,051
Buildout	150,738	48,236	$41,579,432	150,738	100,995	$87,057,225

6.5 Revised Population Projections

Results of the sustainability assessment were evaluated in the context of Buckeye's buildout population projections. From the Buckeye General Plan and Land Use Plan, the buildout population was calculated to be approximately 1.8 million people. This includes all lands within the Buckeye MPA: the Hassayampa model area, the Verrado region, and that portion of the MPA south of the Buckeye Hills. Using the 2007 per-capita use of 174 gpcd (Table 4-2), the total water supply required to support this buildout population would be 360,424 AFY. Of this, over 317,000 AFY would be required in the Hassayampa model area.

For perspective, the total amount of groundwater approved for developments that will be served by Buckeye in the Hassayampa model area is approximately 150,000 AFY. At the time the Buckeye DAWS application was submitted, the total amount of groundwater approved throughout the Hassayampa model area, including all developments and water rights holders, was approximately 300,000 AFY (Town of Buckeye DAWS Application and Hydrology Study, December 2008).

Four pending applications of AWS have been under review by ADWR since the Hassayampa model was delivered in 2006. Conditional analyses have been granted, but the availability of a 100-year water supply has not been demonstrated. The Town's DAWS application, submitted over a year ago, is also under review by the state. Because ADWR requires that these applications rely solely on groundwater, imported water (i.e., CAGRD replenishment water) cannot be included in modeling to prove out the 100-year supply. Effluent recharge/reuse, if currently occurring, can be simulated; the state is evaluating the issue of including projected recharge/reuse of effluent as a source of supply in these applications. Regardless, according to the existing, conservative guidelines from the regulatory agency, the basin is over-allocated.

Revised population projections for buildout were therefore calculated based on the sustainability assessment to evaluate the limitations of the aquifer system. The sustainable population for the Hassayampa model area was calculated to be 748,867 people (Table 6-8). When this number is added to the estimated buildout population for the Verrado and South of Buckeye Hills regions, the revised buildout population totals 970,073. A comparison of the original population projects and the revised projections is provided in Table 6-9.

Table 6-8. Calculations of Sustainable Population at Buildout – Hassayampa Model Area		
Parameter	**Value**	**Source**
Sustainable Groundwater Supply	108,110 AFY	Sustainability Simulation using the Hassayampa groundwater model – Buildout
Effluent Supply	37,838 AFY	Calculated as 35% of the sustainable groundwater pumping
TOTAL SUSTAINABLE SUPPLY	145,948 AFY	Total Groundwater plus Effluent Supplies
Per Capita Water Demand	174 gpcd	2007 gpcd calculated for Buckeye based on total water demand
SUSTAINABLE POPULATION	748,867 people	Buildout population calculated from total sustainable supply and per capita water demand

gpcd = gallons per capita per day
AFY = Acre-Feet per Year

Table 6-9. Original versus Revised Population Projections for the Buckeye Municipal Planning Area			
Buildout Population Projections based on the Town of Buckeye General Plan and Land Use Plan		**Buildout Population Projections based on the Sustainability Assessment**	
Hassayampa Model Area Buildout Population	1,626,311	Hassayampa Model Area Buildout Population	748,867
Verrado Area Buildout Population	89,678	Verrado Area Buildout Population	89,678
South of Buckeye Hills Buildout Population	131,528	South of Buckeye Hills Buildout Population	131,528
Original Buildout Population	**1,847,517**	**Revised Buildout Population**	**970,073**

6.6 Results and Discussion

The most important and influential assumption in the Sustainability Simulation is the beneficial recharge or reuse of effluent by all developments and water providers. This assumption resulted in a significant reduction in pumping, an increase in the areal extent of the sustainable aquifer, and implies that localized recharge and reuse will occur to offset pumping impacts. This high level of effluent management by all water users will be a key building block for sustainability in the region.

The assumption regarding CAGRD replenishment is also a major factor in the sustainability assessment. The benefits of this recharge are apparent, and there is no doubt that replenishment needs to occur in the basin. However, this assumption means that the Town's population growth relies, in part, on replenishment water that is imported. Sources of water supply for replenishment are also finite, unless and until desalination processes become more economically viable. The cost of this reliance on CAGRD replenishment should be rolled into future studies of the actual cost to procure and serve water to the Town's residents.

The results of the sustainability assessment provide a compelling argument for adjusting the Town's population projections to account for limitations imposed by the groundwater supply. Although sufficient groundwater is not available to support the population projections that are reflected in the MAG 208 Plan and the General Plan, it is likely that the Town will address this issue from two perspectives, by both 1) scaling back population densities and 2) securing alternative sources of water supply.

The Sustainability Simulations reflect only the groundwater pumping that was approved when the DAWS application was submitted (December 2008). For some portions of the Buckeye MPA, the groundwater pumping demands that were simulated represent buildout or very close to buildout. However there is one aquifer zone that could potentially sustain additional groundwater development: the central Buckeye region, between I-10 and the Gila River. Buckeye's groundwater pumping in this region totaled approximately 14,000 AFY by the end of the Sustainability Simulation. Pumping for other rights holders was simulated in addition to Buckeye's demands however, to date, and for some time in the future, water quantity is not anticipated to be a problem in the central Buckeye region. But, there are complications due to water quality and regulatory issues, as this region includes the waterlogged area, which has its own special set of circumstances. In terms of pure water quantity, the production potential of central Buckeye has not been fully exploited for the Town's water supply. The potential for the waterlogged area to provide an alternative source of water supply is discussed further in Section 7.0.

7. WATER BALANCE

A water balance presenting the sustainable water supply versus projected water demands for the Town was developed based on the results of the Sustainability Simulation. Projected water demand was defined to be the volume of water for approved Analyses and Certificates of AWS for developments that Buckeye has agreed to serve, plus the corresponding effluent supply. The total projected demand was calculated to be 203,496 AFY (Table 7-1). The projected population that could be supported with this water supply is approximately 1,000,000 people, based on a per capita demand of 174 gpcd (Table 7-1).

Table 7-1. Town of Buckeye Projected Buildout Water Demands Based on Approved Analyses and Certificates of Assured Water Supply	
Total Approved Groundwater Demand	150,738 AFY
Effluent Supply	53,758 AFY
TOTAL Projected Water Demand	203,496 AFY
AFY = Acre-Feet per Year	

7.1 Water Balance and Time to Deficit

The water balance shown on Chart 4 (below) depicts the Town of Buckeye demand curve through 2090, approximately 25 years beyond buildout. Total demand includes: (1) the Town's projected water demand from approved Analyses and Certificates of AWS; and (2) the corresponding effluent supply. Not all approved Analyses and Certificates included effluent demand in the assumptions, however effluent is included in the cumulative demand curve to facilitate a direct comparison with the modeled water supply. The demand curve was also adjusted to account for the slower growth pattern over the last few years (Section 6.2.2); however, the predicted growth from 2010 to 2020 may still be optimistic. The graph shows that by buildout in 2065, total demand reaches its maximum value of 203,496 AFY.

The Town's sustainable supply (groundwater plus effluent) is also presented on Chart 4. A comparison with the demand curve shows that deficits will develop by approximately 2040. The total deficit reaches its maximum of 57,548 AFY by 2065.

The timeline to reach a deficit situation is highly sensitive to a number of planning decisions and factors that will be subject to change, which will either increase or shorten the time at which this deficit would occur. Table 7-2 lists the key factors that will impact the water balance and projected deficit, grouped according to their impact on the timeline to a potential deficit. One of the largest impacts will be the actual volume of the effluent supply in the future. During calendar year 2008, approximately 55 percent of the potable water used by residences and commercial facilities in the Town of Buckeye returned to the sanitary sewer system. This actual rate of return is much higher than the 35 percent that was used for the sustainability analysis, and is based on a water use profile that will change considerably in the future. The long-term return rate may be much less than the calculated value for 2008, and it could even vary considerably from the 35 percent value that is currently considered conservative. (Note: the assumption used in the 2006 Hassayampa modeling simulation for the Town's long-term planning was 30 percent.) As this factor has substantial influence upon the water balance, and could lengthen or shorten the timeline at which a water supply deficit could occur, it is listed in both categories in Table 7-2.

Table 7-2. Factors That Will Shorten or Lengthen the Timeline to Water Supply Deficits

Lengthen	Shorten
Effluent Supply > 35% of total water use	Effluent Supply < 35% of total water use
Increased water conservation	Increases in Consumptive Use
Maximizing use of water deliveries from the irrigation districts in Central Buckeye	Additional approvals of Assured Water Supply in the sub-basin that are not in the waterlogged area
Additional CAGRD recharge within the sub-basin; the location of this recharge is also an important factor (Section 6.4.3)	New demands such as additional golf courses, more turf, or increases in residential densities
Procurement of additional water supplies	Less CAGRD replenishment in the sub-basin

Two measures that the Town can employ in the short term to augment the sustainable water supply are: 1) increased water conservation; and (2) maximization of water deliveries from the irrigation districts. Actual water deliveries from RID and BWCDD were reported to be approximately 1,800 acre-feet in 2007 and 1,400 acre-feet in 2008. This source of water was not included in the sustainability assessment as a source of supply, but the impacts of a long-term supply from the irrigation districts are reflected on the water balance presented on Figure 7-1. A conservative estimate of 2,000 AFY was used for future irrigation district deliveries to the Town. It is likely that the irrigation districts could provide more water to the Town. However, in the context of a 100- to 150-year water supply, the continuous and legal availability of irrigation district water would require more research to make informed decisions if additional growth will be dependent upon this source of supply.

Similarly, water conservation was not accounted for in the sustainability assessment. Conservation measures will have a positive impact on the sustainable supply as the Town's policies are implemented and the per-capita use decreases. The Town's internal per-capita use goal is 125 gpcd. Compared to the actual 2007 value of 174 gpcd (including effluent reuse at golf courses), it is clear that dramatic conservation measures must be employed to decrease water use by 51 gpcd, and this goal will be difficult to obtain in the short- to mid-term. For perspective, slashing the per-capita water use to 125 gpcd would save approximately 41,000 AFY and reduce the deficit 71 percent.

Over the next 20 years, calculations of per-capita consumption will be impacted by potable water use for construction, dust control, and startup landscaping demands as development progresses. The water use calculated for 2008 dropped 9 gallons to 165 gpcd, relative to 2007, and may be attributed to slower growth and a decline in construction-related activities. In the water balance, a reduction in per-capita use to 165 gpcd was assumed for conservation. This assumption is merely a starting point, and should be revised in the future as conservation measures begin to impact the actual reported per-capita usage. Conservation that reduces per capita usage to 165 gpcd would result in additional supply of approximately 7,500 AFY.

The impacts of water deliveries from the irrigation districts and conservation measures implemented by the Town are shown on the water balance as an increase in the sustainable water supply (Chart 4, below). These two measures reduce the deficit to approximately 48,000 AFY, and push out the time to shortage to 2045, an additional 5 years.

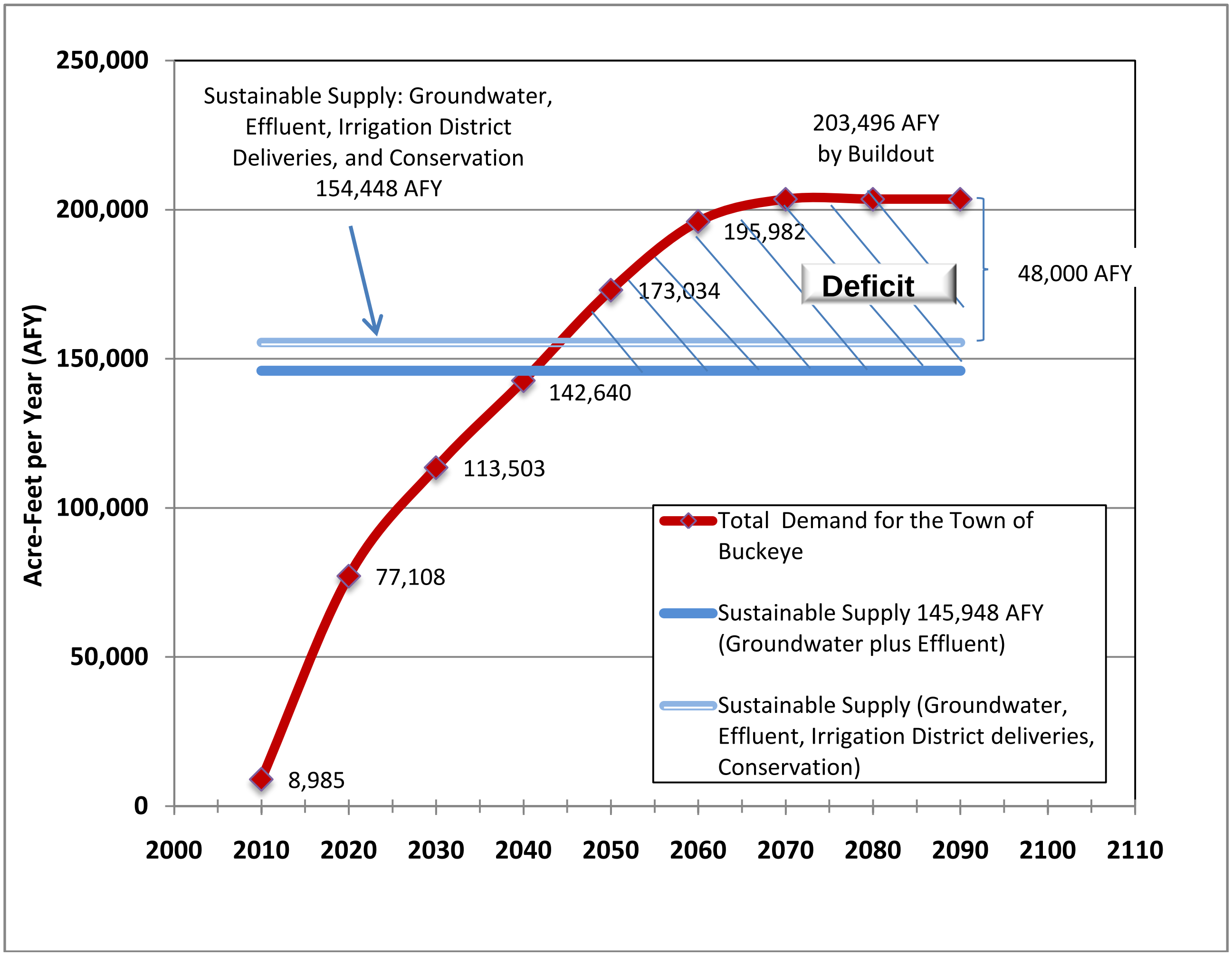


Chart 4. Water Balance: Projected Demand versus Sustainable Supply

7.2 The Waterlogged Area as an Alternative Water Supply

Although the Town is mainly dependent upon groundwater and effluent for their water supply, there are alternative sources of supply that have short- and long-term potential. These sources include: the waterlogged area, RID and BWCDD irrigation district deliveries, long-term Indian leases, additional CAP water allocations, and treated groundwater from Superfund and Water Quality Assurance Revolving Fund (WQARF) sites in the WSRV. An in-depth discussion of all these future sources of supply is outside the scope of this Plan; however there is one key water source that is currently under consideration as a means to augment the Town's supply portfolio: the waterlogged area.

Shown on Figure 2-6, the waterlogged area is a source of water that has been determined to be exempt from consistency with Phoenix AMA goal requirements. Legislation was passed in 1988 that exempted the ACC, BWCDD, and the St. Johns Irrigation District from the conservation required of groundwater users. In addition, this legislation exempted persons using groundwater pursuant to an Irrigation Grandfather Right (IGFR) on certain waterlogged farm areas located in or near these irrigation districts from irrigation water duties and the payment of withdrawal fees. These exemptions became effective on January 1, 1989 and extended until the end of the third management period, December 31, 2009. The exemptions were extended through the fourth management period (through 2019) under legislation approved in 2001. Prior to December 15, 2015, ADWR will review the hydrologic conditions influencing the designated waterlogged areas, consult with representatives of the irrigation districts, and submit a recommendation to the Governor and legislative leadership regarding further extensions of the exemptions.

The status of the waterlogged area is thus subject to periodic review, and exemptions are currently applicable to the irrigation districts and IGFR rights holders located in or near the irrigation districts. Exemptions from conservation requirements are a substantial incentive to use water from this region as a source of supply. The CAGRD replenishment fees, discussed in Section 6.4.4, would be waived for this supply. Even at the current price of $346/AFY, the potential savings from replenishment fees alone could offset the majority, if not all, of the required investments in infrastructure.

7.2.1 Projected Volume and Treatment

As much as 30,000 AFY of groundwater is pumped by BWCDD from dewatering wells located in the waterlogged area to allow crops to be grown. Without this pumping, the groundwater level would rise to within a few feet of the ground surface and fields would not drain. According to the U.S. Bureau of Reclamation, inundation of crops (drowning) occurs when water levels rise within 5 feet of land surface. Water pumped from the dewatering wells is currently disposed via irrigation canals, and eventually routed out of the sub-basin. The water is therefore not beneficially used, in part because it is high in TDS and unsuitable for potable uses or landscape irrigation.

If the waterlogged area water can be treated at a reasonable cost, it could provide an additional source of water supply for the Town's water portfolio and reduce reliance on groundwater pumping and CAP water. Meetings and discussions have been held with ADWR and BWCDD to discuss how the Town can acquire the dewatering water as a potential source of supply. Under certain scenarios, changes in the statutes would be necessary to include the Town as an entity exempt from management goal requirements; however discussions with ADWR indicate that this may be a viable option.

To provide a preliminary estimate of how long hydrologic conditions will maintain waterlogged conditions in this reach along the Gila River, the reported dewatering volume of 30,000 acre-feet was simulated with the Hassayampa model (using the Sustainability Simulation assumptions) for 150 years. Based on this modeling, conditions in the region remained relatively static until 2060, when water levels began to be impacted by groundwater pumping and recharge. These results are based on the assumption that no major changes are made to the hydrologic system. This was not intended to be an assessment of the long-term groundwater supply, but merely an indicator of the persistence of waterlogged conditions assuming a modest level of growth and associated water demands. Tentatively, a range from 20 to 40 years could be used for planning purposes, although additional modeling should be performed to look at worst-case scenarios and assess this further.

A water treatment plant will be required to treat the water from this region prior to use. The treatment of high TDS water can produce up to 25 percent waste by volume in the form of brine concentrate, which must be managed and disposed. Brine disposal is a major challenge in treatment of high TDS waters throughout the world, and future technological advances are expected to produce a cost-effective method to reduce concentrations of TDS in the treated water while simultaneously reducing brine volume, lowering brine disposal costs and identifying potential markets for the salt content of the brine.

In the absence of any new brine disposal options, the technology that would be most efficient, although land intensive, is evaporation beds. Brine treatment would require less land, but is energy intensive. Thus, there is a tradeoff in the cost of land acquisition and facility maintenance versus the cost of power when evaluating the two most prevalent brine disposal options. In preliminary discussions, evaporation beds have been discussed as the preferred disposal option.

The general location for a future plant was tentatively identified as the area in the vicinity of Palo Verde Road, between the BWCDD canal and the Gila River. Town staff identified parcels of land approximately 20 acres in size that could support a treatment plant (requiring approximately 2 acres) and evaporation beds (requiring approximately 18 acres) in this vicinity (Figure 7-3). Two potential sites identified in this process are shown on Figure 7-3: the southwest corner of Palo Verde Road and Carver; and a smaller, 16- to 18-acre property owned by BWCDD between Palo Verde Road and Bruner Road, on the south side of Lower River Road. There are three dewatering wells and three irrigation wells owned by BWCDD in the immediate vicinity of the two sites which could be used to supply water to the plant. The average dewatering well pumping reported from 2004 through 2006 was 12,800 AFY per well, thus three wells would be adequate for supply; one additional well could be utilized for redundancy.

Once treated, water from the plant could be conveyed north along Palo Verde Road to serve the airport and the Westwind development, en route to locations north of the freeway in the Neck region. No pipe sizing or hydraulic modeling of this source has been performed, as the project is still in the early stages of conceptual planning.

7.2.2 Physical, Legal and Continuous Availability

The physical, legal, and continuous availability of this water would have to be demonstrated for it to be a proven source of supply for the Town's DAWS regardless of whether or not the area is designated as waterlogged. Physical and continuous availability of a groundwater supply is typically addressed with groundwater modeling and an assessment of the aquifer system. The simulation of 30,000 AFY of groundwater pumping that was discussed in the previous section is simply a first approximation; a more formal demonstration of physical availability would be required for regulatory purposes. However, the long-term dewatering history, in addition to the high levels of groundwater pumping in the region, strongly support the physical availability of this potential source of groundwater supply.

Legal availability of this water would need to be addressed in a feasibility study that is outside the scope of this Plan. However, collaboration and partnership with BWCDD on this project are being explored by the Town. Changes in current state regulations would likely be required to make this water supply option, including exemptions, viable for the Town; however, the beneficial use of this low-quality water, which is currently being discharged to the Gila River system, would be a powerful incentive for the state regulatory agencies.

The conservation requirement exemptions for the waterlogged area may not be a long-term (i.e., 100 or 150 years), reliable assumption for the Town to make given the recurring evaluation of the exempt status. However, in the short- to mid-term, all indications are that the status quo will be maintained. The potential plant site locations are on the western end of the waterlogged area, the region that has traditionally had some of the highest groundwater levels, so high water levels in this area would persist longest if hydrologic conditions were to change in the future and cause a lowering of the water table. Changing hydrologic conditions, in this case, refer to: a decrease in the amount of imported water used for irrigation (RID); alterations in the contracts for effluent discharged from the 91st Avenue WWTP; and large reductions in irrigated land that would reduce the volume of water routed through canals and reduce aquifer recharge that is currently occurring on irrigated lands. If and when these changes occur, the waterlogged area delineation could shrink, but the proposed sites for the waterlogged area treatment plant could retain the waterlogged status longer than upstream locations, further east.

At some point in the future, the waterlogged conditions in this region will change, but that does not imply that the production potential of the aquifer system will not remain. The Town is uniquely located to adjust to changing conditions in the future, and can utilize infrastructure built for waterlogged area treatment and transmission for other purposes, as required. Once water levels have dropped sufficiently, recharge and recovery will become possible. At that time, the infrastructure for the waterlogged area treatment plant could be converted to other uses, or in some cases, simply be re-permitted: dewatering wells could be re-permitted as recovery wells; the treatment plant could continue to treat pumped groundwater, or be converted to treat effluent; piping and pump stations could still be utilized to deliver water to the north. The flexibility that the Town will have in this regard is an important consideration for this project.

7.3 Additional CAP Allotment as an Alternative Water Supply

The Town has been working to secure additional CAP water as an alternative source of supply, and is tentatively planning on a future allotment of at least 10,000 AFY. The majority of this supply would be delivered to developments bordering the CAP canal in northwestern Buckeye. A portion of the future CAP water could be diverted from the CAP canal into Maricopa County Water District's Beardsley Canal, and then delivered to Arizona American Water Company's White Tanks Regional Water Treatment Facility. The treatment facility is located on the east side of the mountains at Cactus Road and the Beardsley Canal; phase 1 was completed in April 2010.

In February 2010 the West Salt River Valley Central Arizona Project Subcontractors (WESTCAPS) completed a feasibility study for a potential regional water transmission pipeline that would connect the treatment facility to the cities of Avondale, Goodyear, and the southeastern portion of the Town of Buckeye. If this transmission line were to be built, each city would order a portion of their future CAP allotment and have it delivered to the facility for treatment to remove algae and turbidity. The treated water could then be transported to the respective cities via the transmission pipeline. The terminus of the pipeline in the Town of Buckeye is planned to be near Jackrabbit Trail and Yuma Road.

The Town is an active member in WESTCAPS and participated in the feasibility study for the pipeline. If the Town is able to increase its CAP allotment, the transmission pipeline could be one alternative for delivery of the water. Completion of the pipeline to Buckeye would not be until 2025. However, at this time the Town has made no formal plans to participate in the pipeline project, due to the significant costs of the pipeline and the costs of treating the water at the White Tanks Regional Water Treatment Facility.

8. RECHARGE SITE FEASIBILITY ASSESSMENT

A recharge site feasibility assessment was performed to identify potential locations for recharge within the next 20 years that could be permitted as Underground Storage Facilities (USF). This assessment is a preliminary evaluation that was designed to prioritize favorable locations that would warrant further study. It is not intended to definitively eliminate sites from further consideration, except under extreme conditions (i.e., the waterlogged area). The first step in the assessment of future recharge feasibility was to identify those portions of the Buckeye MPA that are most sensitive to pumping stress and would therefore derive maximum benefit from localized recharge.

8.1 Aquifer Recharge Zones

The delineation of the aquifer zones that would most benefit from recharge was based on: 1) initial simulations of future pumping and recharge performed with the Hassayampa model (Brown and Caldwell, 2006), and 2) the Sustainability Simulations performed for this project. As expected, results from both simulation sets were very similar. Zones within the aquifer that experienced severe drawdown in response to groundwater pumping were consistent between studies, varying only by degree of impact as modeling assumptions changed.

A total of 17 aquifer zones were identified and categorized, as shown on Figure 8-1. Zones 1 through 11 are located within the Buckeye MPA; zones 12 through 17 are outside of the MPA and were considered solely in the context of impacts on Buckeye's groundwater resources.

Areas within the Buckeye MPA that were most sensitive to groundwater pumping stresses include the western flank of the White Tank Mountains (the Neck region) and the area north-northwest of the White Tank Mountains; these areas are represented by aquifer zone 5 on Figure 8-1. The aquifer system in zone 5 experiences the maximum water level decline in all simulations, regardless of assumptions. In the Neck region of zone 5, the depth and width of the aquifer system limits the volume of groundwater that can be pumped, and simulations consistently resulted in wells going dry or drawing down the aquifer system to depths below 1,000 feet before the end of the 100-year or 150-year simulation. The region to the north-northwest of the White Tank Mountains is underlain by a thin saturated aquifer as well. Although the basin deepens significantly to the north, this area along the basin margin also dries out in every simulation. Zone 5 would benefit greatly from small- to medium-sized recharge projects, distributed along the flanks of the White Tank Mountains. A large-scale project may be feasible on the north side of the mountains; however, this region is near the Town's planning boundary and thus a large-scale recharge project would also benefit the Surprise planning area. Given this hydrogeologic connection, collaboration with the City of Surprise to develop potential recharge sites could be mutually beneficial.

Other regions that would greatly benefit from recharge include zones 3, 4, and 6. Zones 3 and 4 are located either in or adjacent to the Neck region (between the Belmont and White Tank Mountains), and thus are highly sensitive to pumping stress. Zone 6 is west of the Hassayampa River and is primarily the region occupied by Douglas Ranch. From previous simulations performed with the Hassayampa model, recharge in zone 6 will help alleviate the stress on the Neck region.

Zones 7, 8, and 9 are in the northernmost portion of the Buckeye MPA. Because groundwater gradients at this north end of the sub-basin are directed either south along the Hassayampa River or southeast toward the City of Surprise and the WSRV sub-basin, recharge in these zones should be carefully sited to optimize the benefit to the Town. In zones 7 and 8, recharge facilities should be located as close as possible to the Hassayampa River to ensure that the recharged water moves to the south through the Hassayampa sub-basin. Small, localized projects would be the best choice for zone 9, or alternatively, a larger recharge project could be planned in conjunction with the City of Surprise. At this time, no development has been planned for zone 9.

Zones 10 and 11 were not studied for this Plan as they are outside of the Hassayampa model boundary, and located in the Gila Bend Sub-Basin and WSRV Sub-Basin, respectively. However, there are potential long-term benefits to recharge projects in both zones. In particular, localized recharge could improve groundwater sustainability by offsetting the effects of regional drawdown, especially near Verrado (zone 11), as it is close to the cone of depression in the vicinity of Luke Air Force Base.

Zones 14 and 16 are located outside of the Buckeye MPA, in Tonopah and the City of Surprise, respectively. A regional scale, CAGRD recharge facility is located in both these zones (Figure 8-1). Although both facilities are distal to the Town production wells (the closest facility is 17 miles away), this recharge buffers the regional impacts of pumping in Tonopah and Surprise. Eventually, some of the water stored at these facilities will be recovered, but any water that is categorized as replenishment recharge will remain in the aquifer system. When recovery of the water stored by other entities is initiated, locating the recovery wells as close as possible to the recharge facilities will help lessen the impacts of this future pumping on the regional aquifer system.

Zones 1 and 2 comprise the area between the Buckeye Hills and I-10, and include that portion of Buckeye adjacent to the Gila River. Much of this region is waterlogged (zone 1) and is therefore not eligible for recharge in a 20-year timeframe. Zone 2 is outside of the waterlogged area, and thus is statutorily eligible for permitted recharge; however its proximity to the waterlogged area creates some of the same challenges as zone 1. The further the potential recharge site from the waterlogged area (i.e., further north), the higher the potential for a successful recharge project. Regulatory limitations such as those mentioned above were taken into account in the second step of the recharge evaluation, along with physical and political limitations, as discussed below.

8.2 Approach to Site Assessment

The underlying goal of this assessment is to identify potential sites that could be permitted for recharge facilities and thus gain long-term storage credits for Buckeye over the next 20 years. The approach to assessing sites amenable to recharge focused on 1) physical limitations of the aquifer system, and 2) political or regulatory limitations that could eliminate a site from consideration, regardless of the hydrogeologic potential. The approach was based on a modified version of the reconnaissance level studies performed by the Central Arizona Water Conservation District (CAWCD).

CAWCD has developed and operates six recharge projects in the Tucson and Phoenix AMAs. The combined permitted capacity of the facilities totals 376,000 AFY. Their preference is large-scale, regional basin recharge facilities and they typically perform a comprehensive, reconnaissance level study to identify favorable sites as a precursor to more intensive, site-specific assessments. CAWCD's reconnaissance level studies generally take one to two years to complete.

The approach used by CAWCD was scaled down to perform a preliminary assessment of sites in the Buckeye area. The database of information collected and developed in support of the Hassayampa model (Brown and Caldwell, 2006) was used to support this assessment, and provided valuable information on physical aquifer properties. General criteria used for the assessment are summarized in Table 8-1.

Table 8-1. Summary of Criteria Used in the Recharge Site Feasibility Assessment

Physical Criteria	Description
Depth to water	Source: Hassayampa Model*
Depth to bedrock	Source: Hassayampa Model*
Potential recharge rates	Based on general aquifer parameters from the Hassayampa Model
Slope of land	Regions with high slope (>200-foot rise per 1/2 mile)
Potential for groundwater contamination	Near sources of existing or historical groundwater contamination
Political and/or Regulatory Criteria	**Description**
Land ownership/Land use	Based on generalized Land Ownership from Arizona State Land Dept
Proximity to landfills and sand/gravel operations	Locations from ADEQ (landfills) and field reconnaissance (sand/gravel)
Proximity to existing or planned recharge facilities	All permitted facilities plus facilities with permits in process.
Proximity to the waterlogged area	Recharge limited or precluded by statute

**Brown and Caldwell, 2006*

The study area for the recharge assessment was restricted to the Hassayampa model area, which eliminated the Verrado region and those portions of the Buckeye MPA located south of the Buckeye Hills in the Gila Bend Basin (Figure 8-1.) Sites outside of the Buckeye MPA were not evaluated, except for the northwest portion of the MPA near the mountain front. The site assessment was performed at a resolution of ½ mile by ½ mile, using GIS.

Sites desirable for recharge were identified and categorized in step-wise fashion, beginning with physical criteria. Depth to water was deemed to be the most important physical characteristic, as it relates to the availability of aquifer storage. Thus the first step of the analysis involved classifying the sites based upon depth to water using six general categories. Categories were assigned numerical values ranging from 0 to 5, with 5 being the most desirable for recharge. Political boundaries and regulatory restrictions were then considered.

Buffers were placed around facilities or regions that would inhibit the chances of obtaining a recharge permit, and the initial ranking of any cells falling within the buffer zone was either (1) changed to a zero or, (2) re-assigned to a lower category in cases where mitigating factors could be employed to secure a permit. More subjective guidelines were therefore employed to refine the initial rankings, taking into account the criteria listed in Table 8-1. The ranking for each ½-mile cell was refined during this process using the general guidelines listed below.

- Sites within the waterlogged area or within 1 mile of the waterlogged area were assigned a zero.

- Sites owned by the following entities were assigned to a higher category, unless physical constraints were a factor:
  - U.S. Bureau of Land Management
  - U.S. Bureau of Reclamation
  - Maricopa County
  - Arizona Game and Fish
  - Maricopa County Parks and Recreation
  - Private Land
  - State of Arizona
- Sites within 1 mile of existing recharge facility basins were assigned a zero.
- Variable buffers were used around the linear recharge facility owned by Summit Management: a 1-mile buffer was used at the head of the facility, and ½-mile buffers were used in the southern reaches. Sites located within both buffer zones were assigned a zero.
- Sites within 1 to 2 miles of the Hassayampa Landfill were assigned a zero.
- Sites within ½ to 1 mile of any sand and gravel operation were assigned a zero.
- Sites with a topographic slope greater than 200 feet per half mile were assigned a zero.
- Sites with a shallow aquifer hydraulic conductivity less than 4 ft/day were ranked as a 3, unless already ranked lower for other reasons.
- Sites with a 3, 4, or 5 depth-to-water ranking were adjusted downward when in proximity to existing recharge facilities.

8.3 Results of the Assessment

Two major criteria that weighed heavily in the assessment were depth to water and land ownership. The physical depth represents the aquifer storage potential and will dictate the potential magnitude of a project, while land ownership constraints could render sites unavailable. The general depth-to-water criteria and a description of other key considerations for each rank are presented in Table 8-2. Land ownership for the region is shown on Figure 2-5. Results of the assessment are shown on Figure 8-2 with the higher numbers reflecting more desirable locations.

The aquifer zones described in Section 8.2 were incorporated into the assessment on a qualitative basis. Because the assessment does not definitively preclude sites if mitigating circumstances could allow some flexibility, the need for recharge in certain locations had significant influence on the final rank assigned. For example, zone 5 is a region that would greatly benefit from localized or regional recharge. Although existing, permitted recharge projects are nearby (Tartesso and Summit Management), this area was still ranked relatively highly as recharge could be restricted volumetrically or tied to the level of pumping or observed water levels.

Table 8-2. Recharge Site Feasibility Assessment – Ranking		
Rank	**Depth to Water**	**Description**
0 – Not Considered		Areas that are: located in (or within 1 mile of) the waterlogged area; mountainous regions; outside the Buckeye MPA; very close to landfills or sand/gravel operations; areas with high slope.
1 – Very Low Volume or In Lieu	Variable	Areas that are close to the waterlogged area, existing recharge facilities, landfills, or sand/gravel operations.
2 – Low Volume	< 80 feet	Sites have potential and are rated as Low Volume due to DTW and/or proximity triggers cited above.
3 – Low to Mid Volume	80 – 150 feet	Potentially viable sites for small to mid-volume recharge projects.
4 – Mid to High Volume	150 – 300 feet	Potentially viable sites for mid- to high volume recharge projects.
5 – High Volume	> 300 feet	Minimal limitations from permitting or political boundaries, and physical characteristics amenable to regional-scale facility.

Sites ranked as 4 or 5 were identified as potentially suitable for mid- to high-volume recharge projects, although these sites warrant further consideration in the siting of both regional or localized facilities. A ranking of 3 indicates suitability for local, smaller-scale recharge projects such as WRFs serving a single development or recharging on a sub-regional scale. Three specific locations were ranked very highly in this assessment: the southern flanks of the White Tank Mountains, the western flank of the White Tank Mountains, and the regions on the north, west and south boundaries of the Douglas Ranch property. On the southern flank of the White Tank Mountains, Maricopa County owns tracts of land that contain the FRSs #1, #2 and #3 that protect I-10 and areas south of I-10 from floods and runoff from the White Tank Mountains. The FRSs run roughly parallel to I-10, beginning near Verrado (east) and ending at the Hassayampa River (west). The county owns the land between the freeway and the earthen dams. The land is native desert, relatively flat, and in a location that is not considered to be developable. Given these conditions, a dual use project may be a useful opportunity for this area. Buckeye's Sundance development lies just across the freeway, and the CBWWTP, although further south, has surplus effluent available. This region could support phased recharge with a flexible design of either basins or injection wells. In the short-term, the areas further east near Verrado would be more easily permitted, as the recharged water would move to the east as well as to the south.

The western flank of the White Tank Mountains is identified as zone 5 (Figure 8-1) and was discussed in detail in Section 8-1. This aquifer zone is in the Neck region, and due to the high pumping stresses and physical limitations on the aquifer system, it is also the most sensitive to groundwater withdrawals. This zone is simulated to sustain pumping for no longer than approximately 50 to 60 years into the future, given current demand estimates. As development proceeds in this region, and wells are drilled and brought on-line, this aquifer zone will require not only localized recharge, but also would benefit greatly from larger scale recharge projects near the mountain front. This area warrants additional study with respect to optimal siting of recharge facilities and their impact on future groundwater conditions.

The third region that was ranked highly in the site assessment is the area bounding the Douglas Ranch property on the west and south, near the Belmont Mountains. CAGRD has had great success with their large-scale recharge facility on the southwestern flank of the Belmont Mountains, and the locations near Douglas Ranch on the northern flanks of those mountains may have similar potential. The recharge site feasibility assessment was extended slightly beyond the Buckeye MPA boundary in this region, as this area has 1) high potential for regional scale recharge and 2) close proximity to the CAP canal, which will be beneficial if Buckeye procures surplus CAP water or is successful in expanding its CAP allotment. Because of the bedrock constrictions surrounding this area, recharge at these locations would directly benefit the Douglas Ranch well fields. However, like the regional CAGRD recharge projects, it would also assist with alleviating some of the stresses in the Neck in the future. This area also warrants further study with respect to optimal recharge strategies.

Although the ranking system eliminates sites based on several criteria, the only triggers that definitively preclude sites from being considered are the waterlogged area and the mountains, as recharge facilities in these locations are not permittable or physically feasible. Apart from these regulatory restrictions, most other sites could work if there was incentive to overcome the challenges. For example, sites with very low infiltration rates at the surface could be viable if recharge wells were used to directly deliver recharge water to the aquifer. Or, sites located in close proximity to existing recharge facilities could be permitted in phases to keep pace with groundwater pumping at nearby developments, which "makes room" in the aquifer for recharged water. In regions that are partially built out or where acreage is not available for basin recharge (i.e., Sundance), recharge wells could be used to reduce the footprint of the recharge facility. A few existing locations were identified as Wells Only sites, and are shown on Figure 8-2.

8.4 Pros/Cons of Recharge Methods

This section provides a general overview of recharge methods as a supplement to the recharge site feasibility assessment. A variety of methods have been developed to artificially recharge groundwater reservoirs in various parts of the world; virtually all of these methods are being successfully employed in Arizona. The methods have been classified into four categories (Oaksford, 1985): direct surface recharge, direct subsurface recharge, combined surface and subsurface techniques, and indirect recharge. The pros and cons of each method are discussed below; selected methods that are considered most applicable to the Buckeye region are summarized in Table 8-3.

8.4.1 Direct Surface Recharge

Direct surface recharge is probably the simplest and most widely applied method of artificial recharge, and consists of both in-channel and off-channel facilities. With this method, recharge water travels from the land surface to the aquifer by means of percolation through the soil. In general, direct surface recharge methods have relatively low construction costs and are easy to operate and maintain.

Because percolation through the unsaturated soil zone can transform or remove contaminants from the recharged water via Soil Aquifer Treatment (SAT), these methods can also be protective of groundwater quality. Before relying solely on SAT to provide source water treatment, a careful analysis of source water quality should be made (EWRI/ASCE, 2001):

> "Most of the SAT processes are renewable and sustainable, including denitrification, removal and decomposition of microorganisms, decomposition and mineralization of biodegradable compounds, and volatilization of certain synthetic organic compounds. However, metals, phosphate, fluoride, and recalcitrant organic compounds could slowly accumulate in the SAT system by adsorption, precipitation, or other immobilization."

In-channel facilities include dams, weirs, T-levees, finger dikes, or other structures in the streambed or floodplain to impound and spread the water over as large a wetted area as possible, increasing infiltration volumes. Gillespie Dam located south of Arlington in Buckeye's MPA, is one example of an in-channel facility. This dam has the effect of enhancing recharge in the upstream reaches of the Gila River. Although primarily designed as a storage and diversion dam supporting irrigated lands to the south, the dam backs up flows in the river for several miles, and has increased recharge to the extent that water levels upstream were raised by approximately 22 feet.

Off-channel facilities consist of excavated or constructed ponds, basins, or ditches. Recharge via an old gravel pit is one of the off-channel options that is available to Buckeye, and would be worth exploring, particularly along the Hassayampa River. A gravel pit has the benefit of likely being excavated to a depth below any shallow impermeable layers, and most are located close to the river, where infiltration rates are typically high.

Many of the existing large-scale artificial recharge projects in Arizona employ direct surface techniques, typically consisting of engineered, constructed infiltration basins. This is the method used exclusively by CAWCD in the Phoenix and Tucson areas.

An alternative to engineered basins that is employed in Arizona is recharge via natural, ephemeral streambeds and washes, or linear recharge. Because ephemeral washes flow only in response to rainfall events, they are dry most of the time and provide an attractive option for small-scale recharge projects. An abundance of natural drainages and washes ensures that a discharge point is close to the source water, thus reducing delivery costs. The Summit Management linear recharge facility along the Hassayampa River is currently recharging near, or at, their permitted volume of 25,000 AFY, although the permitted reach of 3.3 miles limits the ability to recharge under certain conditions, when surface flows pass the facility boundary. The permit is being modified to extend the facility downstream (11 miles) and increase the permit volume (Figure 8-2). One disadvantage of the natural, linear recharge facility is that changing conditions can impact the distance that the water travels before infiltrating completely. If the permit is restricted to a specific downstream boundary, daily management of the facility may be necessary.

Groundwater recharge with direct surface infiltration may not be feasible when:

- Land is not available or is expensive;
- Surface soils are not amenable to recharge (not permeable);
- Unsaturated zones have restricting layers such as caliche horizons or thick packages of clay; or
- The aquifer is confined.

8.4.2 Direct Subsurface Recharge

Direct subsurface recharge techniques convey water directly into an aquifer. These methods can solve some of the logistical and physical problems with direct surface methods, including reducing land requirements and moving water down past impermeable surface soils and/or restrictive layers in the vadose zone. Direct subsurface recharge methods can access deeper aquifers and even be designed to target specific horizons within the aquifer system, a most desirable trait when the aquifer is comprised of alternating layers of fine-grained and coarse-grained materials, which is generally the case in the Buckeye region. These subsurface methods are more expensive to construct and maintain, and are susceptible to clogging by suspended solids, biological activity, or chemical impurities. With all methods of subsurface recharge, the quality of the source water is a concern as the recharged water enters the aquifer without the filtration that occurs when water percolates through the unsaturated zone, thus considerable pre-treatment may be required.

Direct subsurface methods used successfully in southern Arizona include: vadose zone wells, injection wells that deliver water directly to the aquifer, and Aquifer Storage and Recovery (ASR) wells that are designed to both recharge and recover (or pump) water.

Vadose zone wells or dry wells are a relatively inexpensive (versus other types of wells) direct subsurface method that solves the problem of impermeable surface soils or shallow caliche that inhibits downward percolation. If the depth to the aquifer is deep enough, vadose zone wells still have the benefit of SAT to address water quality, potentially eliminating a costly pre-treatment step. Clogging and biofouling are still a potential problem, however, and maintenance of the system is one of the drawbacks. The City of Scottsdale operates a very successful direct subsurface recharge project with vadose zone wells. The source water quality is very good, as it is treated by reverse osmosis (RO), thus helping to eliminate clogging and water quality issues. RO water is, however, quite aggressive, and can mobilize constituents from the vadose zone. Initial planning of a recharge project that proposes vadose zone wells may well include planned replacement; as the costs of maintenance go up, it can be more cost efficient to replace than maintain.

Injection wells can be designed to maximize recharge to the most permeable portions of the aquifer, or even to multiple aquifers. All aquifer types can be recharged via injection wells, including confined and semi-confined aquifers. The wells can be designed for gravity flow or injection can be pressurized. As with other direct subsurface methods, the footprint of the facility can be small but the construction and maintenance costs are relatively high. Source water quality must be monitored and expensive pre-treatment may be required to 1) protect aquifer water quality, and 2) minimize the rehabilitation of the well if clogging or biofouling occur. Aquifer water quality must be monitored for the creation of disinfection byproducts (i.e., trihalomethanes and/or haloacetic acids) and/or mobilization of inorganic constituents from the aquifer solids. Injections wells may be injection-only, or designed for both aquifer storage and recovery.

ASR wells are a subset of injection wells, and are the most costly of the direct subsurface methods that are prevalent in Arizona. However, the footprint of such a facility is small, and this recharge method is viable in regions that have already been built out, or have no undeveloped land available. ASR wells can be used to manage seasonal imbalances between water demands and water availability. The flexibility to pump during the summer season and recharge during the winter season would be a useful water resources management tool for the Town. Periodic pumping can be used to help remove accumulated solids, helping to overcome the clogging issues typically encountered in recharge wells. Source water quality must be acceptable and must be monitored, as damage to the well can occur and is costly to remedy. ASR wells have the same monitoring requirements as injection-only wells.

8.4.3 Combination Surface-Subsurface Methods

Combinations of direct surface and subsurface techniques can be used to meet the goals of the recharge facility, including subsurface drainage (collectors with wells), basins with pits, shafts, and wells. The most likely combination for the Buckeye region would be basins and wells. The pros and cons of combination methods are the same as for their individual components, which are summarized in Table 8-3.

8.4.4 Indirect Recharge Techniques

Indirect methods of artificial recharge include: (1) the installation of groundwater pumping facilities or infiltration galleries near hydraulically-connected surface waters (streams or lakes) to lower groundwater levels and induce infiltration (induced recharge); and (2) modification of aquifers to enhance or create groundwater reserves. The effectiveness of the induced recharge method depends upon the proximity of surface water bodies, the hydraulic conductivity (or transmissivity) of the aquifer, the area and permeability of the streambed or lake bottom, and the hydraulic gradient created by pumping. Inducing recharge by lowering the groundwater levels around a stream or lake can be effective; however, the depletions to the surface water bodies may be unacceptable, particularly with respect to surface water rights. Aquifer modification includes the introduction of structures that impede groundwater outflow or that create additional storage capacity. None of the indirect recharge methods are included in Table 8-3, as it is not a recharge option that is currently available to Buckeye.

8.4.5 Other Methods

Groundwater barriers or dams have been built within river beds or washes to obstruct and detain groundwater flows so as to increase the storage capacity of the aquifer. One of the dams built in northern Arizona is an indirect recharge facility, as it was constructed over highly permeable limestone. Water retained behind the dam quickly infiltrates through the limestone bottom, and recharges the aquifer system with water that would normally have continued further downstream, beyond the limestone outcrops, eventually infiltrating or flowing out of the basin. Although not originally designed for this purpose, the dam is increasing storage in its vicinity and focusing recharge in a particular area. This method can be considered a hybrid between an in-channel facility and an indirect recharge technique.

A hybrid approach that fits in between surface infiltration and injection wells is groundwater recharge via adits and shafts. This technique is being explored as both a supply mechanism (pumping) and a recharge method on inactive mine properties in Arizona.

Another management method of increasing groundwater in storage is in lieu recharge. This is the practice of substituting a surface water supply or effluent supply to groundwater users in exchange for the right to a volume of groundwater equal to the amount of water the user would have pumped. In lieu recharge, which could be considered an indirect recharge method, is discussed in the context of the treated effluent from the Central Buckeye WWTP (Section 5).

Table 8-3. Pros and Cons of Recharge Methods

Direct Surface Methods	Pros	Cons
Constructed infiltration basins	• Generally low construction costs • Easy to operate and maintain. Can improve quality of recharged water through Soil Aquifer Treatment (SAT) • Direct control over wetted acreage • Maintenance is relatively simple, with periodic drying cycles and cleaning to remove fines and stop formation of algal mats	• Land intensive, particularly for large-scale projects • Require permeable soils and no severely restricting layers in the vadose zone • If source water chemistry changes, SAT efficacy must be revisited • Potential algae and mosquito issues • Floodplain locations may be susceptible to flooding and destruction of berms
Linear recharge via natural streambed/wash	• Low cost; low maintenance • Can improve water quality through SAT • In many cases, natural channels are in close proximity to source areas • Infiltration rates, particularly along larger streams, can be relatively high	• Minimal control over distances the water will travel before recharging (unless channel modifications are allowed) • Effluent recharged via natural channels can earn Long-Term Storage Credits for only 50% of the total volume
Old gravel pit	• Low cost; low maintenance • Already excavated below any shallow impediments to infiltration • If close to a stream, are designed to handle flood flows • Could improve quality of recharged water through SAT • Infiltration rates, particularly along streams, can be relatively high	• May be land intensive • If source water chemistry changes, SAT efficacy must be revisited • May be difficult to keep clean, to maintain acceptable infiltration rates • May need excavation • If close to a river, the depth to water may be more shallow than locations away from the river (i.e., less storage capacity)
Direct Subsurface Methods	**Pros**	**Cons**
Vadose Zone Wells	• Less expensive than injection wells or ASR wells • Less stringent permitting requirements than injection or ASR wells • May not require pre-treatment • Do not require large land purchases	• Higher construction costs and higher maintenance costs (relative to surface methods) • Water quality concerns if source water is not relatively pristine • Clogging issues

Table 8-3. Pros and Cons of Recharge Methods		
Direct Subsurface Methods	**Pros**	**Cons**
Injection Wells	• Can directly access deep aquifer systems • Can recharge confined or semi-confined aquifers • Can access targeted zones with high permeability • Do not require large land purchases • Can be pressurized or gravity-flow fed • Recharge to several aquifers can be achieved, while maintaining hydraulic isolation between aquifers, if desirable	• Much higher construction and maintenance costs (relative to surface methods) • May require pre-treatment to address water quality • Extensive permitting requirements • Water quality monitoring required • Clogging issues
Aquifer Storage and Recovery (ASR) Wells	• Can directly access deep aquifer systems • Can recharge confined or semi-confined aquifers • Can access targeted zones with high permeability • Do not require large land purchases • Can be pressurized or gravity-flow fed • Periodic pumping of the well can help alleviate clogging issues • Can help address seasonal imbalances in water demand: pumping in summer and recharging in winter • One facility provides for both recharge and production	• Much higher construction and maintenance costs (relative to surface methods) • May require pre-treatment to address water quality • Extensive permitting requirements • Water quality monitoring required • Possible clogging issues

9. FUTURE EFFLUENT RECHARGE/REUSE

A compilation of data in master plans for MPCs and developments within the study area was performed to assess future supply of and demand for treated effluent. The results from this compilation are organized by the MAG 208 Plan wastewater service areas. The original wastewater service area boundaries were revised along the Gila River to exclude regions within the floodplain and to be consistent with existing, approved wastewater models for proposed developments. Boundaries were also revised north of I-10 to exclude flood control district properties and high slope areas.

Figure 9-1 depicts the revised MAG 208 Plan wastewater service areas, locations of existing and proposed WRFs from the MAG 208 Plan, and existing effluent distribution and transmission lines.

9.1 Actual versus Projected Effluent Supply

The quantity of effluent that is projected to be available is a key issue for the Town due to its importance as a source of water supply. At this time, the actual data represent a very small percentage of the total anticipated population, and are based on a usage profile that will change substantially in the future. There is however, a range of values that recur in the literature, in nearby communities, and in planning documents that provide some guidance as to the quantities that can be anticipated. These values range from 25 to 53 percent of total water use (Table 9-4, Hassayampa Model Report, Brown and Caldwell, 2006).

Actual data for the Town from 2007 and 2008 indicate that the effluent supply ranges from 26 to 33 percent of the total water use, which was comprised of groundwater pumping, irrigation district deliveries, and Valencia water use (Table 9-1). Groundwater pumped from individual domestic wells and wastewater that is treated via individual septic systems within the Town's service areas are not reflected in Table 9-1. The impacts of individual wells and septic systems would cancel out to a certain degree, and are not thought to be large enough to substantially change the results.

For comparison to groundwater modeling assumptions used for the Hassayampa model (Brown and Caldwell, 2006) and the Sustainability Simulations (Section 6-3, this report), the effluent supply as a percentage of total groundwater pumping was calculated to be 33 to 41 percent. This compares very favorably to the range used for the Town's planning: 30 percent was used in the original Hassayampa model, and 35 percent was used in the Sustainability Simulation (Section 6.0).

Table 9-1. Total Water Used that Returns as Effluent Supply		
Source	**2007**	**2008**
Groundwater	4,773	4,496
Irrigation Dist Deliveries	1,796	1,423
Valencia Water Use*	1,561	1,561
TOTAL	**8,130**	**7,480**
Treated Effluent	2,121	2,496
Effluent as a Percent of Total Water Use	26%	33%
Effluent as a Percent of Groundwater Pumping**	33%	41%

**Valencia Water Use based on July 2007 through June 2008 total water use, minus irrigation and construction.*

***Is directly comparable to the Sustainability modeling assumption that 35 percent of groundwater pumped would be returned as effluent available for reuse or recharge.*

Note: Includes effluent generated in Global Water's Service Areas, but not water used.

Projected effluent supply at buildout for each of the wastewater service areas is summarized in Table 9-2; projected supplies are presented from two separate sources: the Sustainability Simulations and the MAG 208 Plan. When comparing these estimates, it is important to note that the Sustainability Simulation is based on *approved* applications for groundwater supply. The three pending applications for Douglas Ranch, Festival Ranch, and Sun Valley South are not reflected in these numbers although they are included in the estimates based on land use and the MAG 208 Plan plant capacities. Similarly, the Central Buckeye and Sundance sub-basins are not completely built out, thus the sustainability estimates are not directly comparable to the land use and MAG 208 Plan projections.

There is a considerable difference between actual versus projected wastewater generation and the resulting effluent supply, largely because of the planning requirements for infrastructure. Wastewater generation design criteria are deliberately conservative, overestimating wastewater flows in the design of collection systems and treatment facilities. The Town's design criteria stipulate that wastewater systems be designed to support 100 gpcd of flow, or 66 percent of the total per-capita water use of 150 gpcd.

When estimating total effluent supply, however, adjustments to the design criteria are typically employed to be more realistic in the estimation of this supply source. This approach was used for the Cipriani Master Wastewater and Reuse Report (CMX, 2006) and in the Festival Ranch Reclaimed Water Master Plan (CVL, 2006). The approach used by CMX, which assumes that 64 percent of the wastewater treated at the WRFs would be available as an effluent supply, was followed in this study.

Table 9-2. Estimates of Projected Effluent Supply by Wastewater Service Areas

Wastewater Service Areas and Corresponding Water Reclamation Facilities	Sustainability Simulations Section 6.0 (approved AWS Applications only*)		MAG 208 Plan (approved plus pending AWS Applications)	Buildout Land Use from the Buckeye General Plan (approved plus pending AWS Applications)
	Effluent Supply equal to 35% of Total Groundwater Pumping*	Effluent Supply based on Sustainable Groundwater Pumping	64% of the Water Reclamation Facility Capacity	64% of Wastewater Generation
Anthem - Sun Valley South WRF†	2,624	1,421	3,226	4,007
Central Buckeye WWTP	2,454	2,454	32,832	29,106
Cipriani WRF	3,435	3,435	8,602	8,646
Douglas Ranch WRF†	8,254	4,812	22,867	29,602
Festival Ranch WRF†	11,570	5,902	12,401	11,866
Gila 85 WRF	0	0	6,523	5,574
Gila Hassayampa WRF	0	0	5,591	5,352
Hassayampa North WRF	0	0	6,738	11,786
Palo Verde Road WWTP	0	0	8,387	6,100
Sundance WRF	1,582	1,582	9,964	9,186
Sun Valley WRF	6,769	5,799	9,462	8,584
Tartesso East WRF	3,557	2,683	7,670	9,014
Tartesso West WRF	10,115	7,352	17,348	15,985
Trillium West WRF	2,398	2,398	2,294	2,365
TOTAL within Study Area	**52,758**	**37,838**	**153,905**	**157,173**

**Effluent Supplies from the Sustainability Simulation do not represent full buildout conditions in most sub-basins, particularly those that are shaded.*

†Communities within these Service Areas have a pending AWS Application.

AWS = Assured Water Supply

9.2 Effluent Demand

Demand for treated effluent was compiled from developers' reclaimed water master plans, where available (Table 9-4), and supplemented with information from individual water and wastewater master plans and planning documents provided by the Town. Formal reclaimed water master plans have been developed for Cipriani, Festival Ranch (Sun City Festival), and Village 3 in Anthem Sun Valley South. All of these master plans reflect both approved and pending AWS applications.

Table 9-4. CMPs or Wastewater Service Areas with a Formal Reclaimed Water Master Plan

Wastewater Service Area	Reclaimed Water Master Plan?	Schematic or GIS files of Existing or Planned Reclaimed Water Pipe
Cipriani WRF	x	x
Festival Ranch CMP	x	x
Spurlock CMP		x
Anthem Sun Valley South	x	x
Sundance		x
Douglas Ranch CMP	x*	
Central Buckeye WWTP		x

**208 Plan Amendment*

In the cases where effluent demand was not explicitly defined, demand was estimated based on land use water demands and acreage from individual water and wastewater master plans. The level of detail in these plans varied widely. Large data gaps are evident, and no data were available for the Palo Verde Road, Sun Valley, and Trillium West wastewater collection sub-basins. The resulting summary of effluent demand is therefore roughly estimated, but is useful for comparison purposes, and indicates data gaps where additional, detailed information on effluent planning will be required.

Land use categories that use significant amounts of reclaimed water traditionally include golf courses, agriculture, lake systems, parks, schools and athletic fields, private and public landscaping, and industries with large cooling or process water demands. Effluent demand for the wastewater service areas within the study area is summarized in Table 9-5, and includes the four main categories of non-potable demands that are typically reflected in master plans: golf courses, lakes, parks, and schools. Central Buckeye and Sundance are not included in this demand summary, as the reuse plans for these two regions are following an approach more appropriate to local conditions and the status of their existing systems.

County properties located within the wastewater service areas are not included in the effluent demand summary at this time. These lands include: Montana Vista, Buckeye Ranchos, West Phoenix Estates, and Hopeville.

Table 9-5. Summary of Estimated Effluent Demand by Wastewater Service Area																	
Wastewater Service Area	**Master Planned Community (Mpc) Or Development**	**No. of Golf Courses**	**AVG Golf Course Demand (MGD)**	**MAX Golf Course Demand (MGD)**	**No. of Parks**	**Park Acres**	**AVG Park Demand (MGD)**	**Park Demand (Gallons/Acre/Day)**	**MAX Park Demand (MGD)**	**No. of Schools**	**School Acres**	**AVG School Demand (MGD)**	**MAX School Demand (MGD)**	**Lake Demand (MGD)**	**Total Avg Demand (MGD)**	**Total Avg Demand (AFY)**	**Comments**
Anthem Sun Valley South	Sun Valley South Village 3	3	1.5			96	0.13					0.34		0.11	2.08	2,330	
Cipriani	Cipriani MPC	0				78.2	0.21	2,685	0.41	4	82.9	0.28	0.56		0.49	549	Demand for Stone House Wash is simply the effluent supply remaining after park/school demands are met, and represent a combination of recharge/reuse.
	Stone House Wash Conserv. Area					146	5.21	35,808	4.73						5.21	5,836	
	Desert Creek									4	45	0.04			0.04	45	
Douglas Ranch	Douglas Ranch MPC	8	4.32			1573	5.40	3,436						0.95	10.67	11,950	Large central park; construction demand 120,000 gallons/acre
	State Land					55	0.10				25	0.02			0.12		
	Eastern Properties					95	0.17				20	0.02			0.19		
Festival Ranch	Festival Ranch - North (OMR)	1	0.63												0.63	703	
	Sun City Festival /Fest Foothills	2	1.26	2.0		35.5	0.06	1,800			15	0.01		0.10	1.44	1,608	Two 18-hole golf courses; each with an 11-acre lake, initially filled with CAP water
	Spurlock Ranch MPC	0			11	285	0.44	1,547		4	85	0.08			0.52	580	
	Sun Valley (north 1/2)																
Palo Verde Road	Silver Rock																
	Westwind																
Sun Valley	Sun Valley MPC (south 1/2)							1,354									
Tartesso East	Tartesso MPC					145	0.26	1,800	0.26	10	144	0.13			0.39	437	
Tartesso West	Elianto and Valley Del Sol	0				71	0.28	4,000	0.51		80	0.10	0.17		0.38	426	
	Montiere	0			5	27.2	0.58	21,180		1	13.5	0.01			0.59	658	
	Mirielle (Sun Valley South)	0			22	90.5	0.36	4,000	0.72	1	12.9	0.01			0.37	418	Some mention of a golf course, but no data presented; large 15-acre village park
	Sun Valley South Village 2																
	Tartesso West MPC					55.8	0.52	9,293			132	0.12			0.64	714	Park demand includes water feature
	Valle Del Rio																
Trillium West	Trillium MPC																
TOTALS		**14**	**7.70**			**2,635**	**13.71**					**1.12**		**1.16**	**23.44**	**26,254**	
TOTALS (AFY)			**8,626**				**15,076**					**1,254**		**1,299**		**26,254**	

Estimated based on design criteria (i.e., 1800 gpad for turf) or similar demands (i.e., golf courses)
Incomplete totals
AFY = acre-feet per year
MGD = million gallons per Day
OMR = Oasis Management Resources

All planning data compiled in Table 9-5 is based on population projections and growth scenarios prevalent at the time the master plans were submitted to the Town, typically they date back to the time period from 2005 to 2008. The data therefore do not reflect any revisions to population densities or buildout plans in response to the downturn in the economy.

A total of 15 golf courses are planned within the study area, which includes the 14 courses listed in Table 9-5 plus the existing Sundance golf course. According to Town staff and based on master plans submitted to date within the Central Buckeye and Sundance wastewater service areas, no additional golf courses are anticipated in the Central Buckeye or Sundance service areas. All golf courses will be supported by reclaimed water, as will lake demand, although in some instances CAP water augments the reclaimed water supply for filling of lakes.

By far the largest demand for reclaimed water is for park irrigation, totaling 15,076 AFY by buildout. All parks are reflected in Table 9-5 regardless of size; however it may not be practical or cost-effective to install reclaimed water lines to small pocket parks widely scattered throughout a development. Note that Cipriani park irrigation demands include the Stone House Wash Recharge Facility, which was used to balance the water budget by utilizing the remaining Cipriani-generated effluent supply after park and school demands were satisfied. Without the Stone House Wash demand of 5.21 MGD, park irrigation demand totals 9,240 AFY for those facilities included in the summary. Higher-than-average park demand is also reflected in Tartesso West and Montiere.

The use of treated effluent for construction water and dust control is an important category of reuse that is not reflected in Table 9-5. An estimated 120,000 gallons per acre was calculated for construction water demand in the Douglas Ranch 208 Plan Amendment (CVL, 2006); the maximum annual demand was calculated to be 1,555 gpm. The acreage under construction and the timing of development will result in widely varying demands for construction water across the MPA. This is however a long-term non-potable demand that should be met using treated effluent, or another source of supply such as irrigation district water or CAP water.

9.3 Effluent Supply Versus Demand

A general comparison of effluent supply versus demand is provided by wastewater service area in Table 9-6. The surplus and deficits shown in Table 9-6 illustrate the substantial differences in effluent supply estimates. Note that the effluent supply from the sustainability simulations is based solely on groundwater pumping and an effluent supply from *approved* AWS applications, whereas the MAG 208 Plan estimates of effluent supply for the Douglas Ranch, Festival Ranch, and Sun Valley South MPCs include *approved and pending* AWS applications.

A rigorous water balance to assess the surplus and deficits is not warranted considering the data gaps, the pending AWS applications, and the issue of sustainability with respect to population. Despite these limitations, surplus effluent supplies appear to be available in the central portion of the Hassayampa Sub-Basin, within the Festival Ranch, Tartesso East and Tartesso West service areas. According to master plans for these regions, the excess will be recharged.

Table 9-6. Effluent Supply versus Demand (AFY)					
Wastewater Service Area	Effluent Supply		AVG Effluent Demand	Surplus or Deficit	
	Sustainability Simulations	MAG 208 Plan		Based on Sustainability Simulations	Based on MAG 208 Plan
Anthem Sun Valley South†	1,421	3,226	2,330	-909	896
Cipriani*	3,435	8,602	6,384	-2,949	2,218
Douglas Ranch†**	4,812	22,867	14,309	-9,497	8,558
Festival Ranch†	5,902	12,401	2,891	3,011	9,510
Palo Verde Road	--	8,387	--	--	--
Sun Valley	5,799	9,462	--	--	--
Tartesso East	2,683	7,670	437	2,246	7,233
Tartesso West	7,352	17,348	426	6,926	16,922
Trillium West	2,398	2,294	--	--	--
TOTALS	**33,802**	**92,257**	**26,430**	**-825**	**45,684**

**Cipriani demand includes the Stone House Wash Conservation Area*
***Douglas Ranch demand includes 12,298 AFY of reuse plus 2,011 AFY average construction water demand*
†Communities within these Service Areas have a pending AWS Application.
Service areas with incomplete effluent demand data
AFY = Acre-Feet per Year

9.4 Seasonal Effluent Demand

The reuse of effluent is limited by the location and magnitude of non-potable water demands. In all cases, the individual developers' master plans predict an effluent supply far in excess of non-potable demand, even during the summer season when demands increase substantially. This is partially due to the highly conservative assumptions required for sizing the wastewater infrastructure. In reality, the supply of treated effluent available for reuse will be much lower. However, the seasonal nature of turf demand for park and golf course irrigation will still result in an excess of treated effluent available in the winter months. The seasonal variations in supply and demand are managed via discharge to canals, washes, or rivers, or via recharge facilities designed to dispose a portion of the treated effluent supply.

Maximum lake evaporation and turf demand for parks, golf courses, and schools in the region is during the month of July. This maximum demand, where available, is presented in Table 9-5 and is approximately twice the average demand. Monthly demand factors for treated effluent based on the relative consumptive use of water by grasses in Table 9-7 illustrate the seasonal variability. The increased demand in July versus January can thus differ by a factor of 4.5 for turf grasses (July demand factor divided by January demand factor). The surplus supply in January therefore provides the design constraint for infrastructure to utilize excess supply.

Table 9-7. Treated Effluent Monthly Demand Factors	
Month	**Demand Factor***
January	0.44
February	0.50
March	0.70
April	0.84
May	1.03
June	1.65
July	1.98
August	1.72
September	1.18
October	0.86
November	0.60
December	0.48

** Based on the relative consumptive use of water by grasses per the Blaney-Criddle model (CMX, 2006)*

Monthly effluent supplies were calculated from the total annualized estimates in Table 9-6, assuming a constant supply of effluent from month to month, and were then compared with the maximum demand (Table 9-8). The calculation of surplus and deficits in maximum effluent supply versus demand are extremely preliminary. An updated analysis should be performed when the pending AWS applications are resolved, and all data gaps are filled.

Table 9-8. Maximum (July) Effluent Supply versus Demand (AFY)					
Wastewater Service Area	**July Effluent Supply**		**July Effluent Demand**	**Surplus or Deficit**	
	Sustainability Simulations	**MAG 208 Plan**		**Based on Sustainability Simulations**	**Based on MAG 208 Plan**
Anthem Sun Valley South†	118	269	392	-273	-123
Cipriani*	286	717	1,074	-787	-357
Douglas Ranch†**	401	1,906	2,406	-2,005	-501
Festival Ranch†	492	1,033	486	6	547
Palo Verde Road		699	--	--	--
Sun Valley	483	789	--	--	--
Tartesso East	224	639	74	150	566

Table 9-8. Maximum (July) Effluent Supply versus Demand (AFY)					
Wastewater Service Area	July Effluent Supply		July Effluent Demand	Surplus or Deficit	
	Sustainability Simulations	MAG 208 Plan		Based on Sustainability Simulations	Based on MAG 208 Plan
Tartesso West	613	1,446	72	541	1,374
Trillium West	200	191	--	--	--

**Cipriani demand includes the Stone House Wash Conservation Area*

***Douglas Ranch demand includes 11,950 AFY of reuse plus 2,011 AFY average construction water demand*

†Communities within these Service Areas have a pending AWS Application.

Service areas with incomplete effluent demand data

AFY = Acre-Feet per Year

9.5 Guidelines for Reuse/Recharge

General recharge and reuse guidelines have been developed for the Town based on the results of sustainability modeling (Section 6.0), the recharge site evaluation (Section 8.0), results of simulations performed with the Hassayampa model for this study and for the Town's DAWS application, and discussions with Town staff. These general guidelines are listed below.

- No discharge of treated effluent will be allowed that is not supported by a recharge permit, except for emergencies. Master plans that include unpermitted discharge as an effluent management plan will not be approved.
- For recharge of treated effluent, permitted recharge via constructed facilities (basins or recharge wells) is the Town's preferred option, and is required for long-term effluent management. Permitted recharge via managed facilities is acceptable as an interim solution, but must be converted to constructed facilities within 3 years of startup. Unpermitted discharge or recharge will not be approved.
- Developments shall permit and install recharge wells, or permit and build recharge facilities prior to startup of the water reclamation facility. In this way, during the early stages of growth, when treated effluent volumes are not sufficient to warrant distribution via reuse piping, the Town will still receive credit for the recharged volumes.
- Potable water should not be used to irrigate properties that are located in the vicinity of irrigation district canals and laterals. The region that could be served by irrigation district water is located south of the RID and Buckeye Canals, and is shown on Figure 9-2. A large network of laterals and ditches is used to move water within the irrigation districts; diverted water can be routed to the south under the influence of gravity using existing infrastructure. If this water supply can be secured with a long-term renewable contract, more elaborate underground infrastructure to move water could be constructed.
- CAP water should be used as a renewable source of non-potable supply in the central portion of the Buckeye MPA, particularly for those properties adjacent to the canal, including Douglas Ranch, Festival Ranch, Sun Valley, Trillium, and Spurlock Ranch.
- For golf course or other turf irrigation demands in developments adjacent to the Hassayampa River Recharge Facility, water stored by Global Water (previous owner) or Summit Management (current owner of the facility) could be purchased to augment

groundwater supplies. Recovery wells installed within a mile of the recharge facility could provide a local source of water for golf course irrigation that may be more cost effective than the infrastructure to route water from the WRFs, which are typically located at the extreme down-gradient point in the wastewater service areas. MPCs with boundaries that are less than a mile from the Hassayampa River Recharge Facility include Douglas Ranch, Sun Valley, Trillium, Montiere, and Tartesso West.

- Vadose zone or aquifer zone recharge wells, where feasible, should be installed in the odor control buffer zone around the WWTPs. The wells shall be permitted to earn long-term storage credits for the Town. Wastewater service areas located in the waterlogged area are an exception to this guideline for as long as the area retains its waterlogged status.
- Water truck filling stations shall be installed at all WWTPs or WRFs to provide construction water as needed for additional phases of development within the WRF service area, or for construction underway in nearby service areas.
- Where feasible, groundwater pumped during pumping tests shall be stored and/or made available for turf irrigation or construction water demands. The Town should be contacted during the planning stages of these tests to help identify potential uses for this water.
- The Neck region and the area north-northwest of the White Tank Mountains are the aquifer zones most impacted by groundwater pumping. Recharge in Zones 3, 4, 5 and 6 (see Figure 8-1) will help alleviate pumping stresses and reduce costs for groundwater pumping by propping up the water levels. Regional recharge facilities permitted to store both CAP water as well as treated effluent should be a priority.
- Effluent supplies from the north and south are routed toward the central Neck region, for reuse or recharge, to help alleviate the stress of pumping on this sensitive zone.

The waterlogged area poses a number of unique challenges to effluent management that require additional guidelines.

- Recharge of treated effluent in the waterlogged area will not earn long-term storage credits for the Town. Treated effluent must therefore be routed north, outside of the waterlogged area boundary for recharge.
- Reuse of treated effluent in the waterlogged area is not the preferred effluent management strategy. The waterlogged area is generally coincident with the boundaries of the BWCDD irrigation district boundaries, thus non-potable demands can potentially be satisfied by this alternate supply source.
- Maximum benefit to the Town is derived from recharge or reuse outside of the waterlogged area that offsets groundwater pumping (reuse) or earns long-term storage credits (recharge). In the waterlogged area and in the general area between I-10 and the Gila River, all efforts should be made to keep the effluent supply as far to the north as possible, at higher elevations, to reduce the amount of energy required to move water uphill. As long as waterlogged conditions persist, a portion of the treated effluent supply must be moved to the north for maximum benefit. Adding a scalping plant in the Central Buckeye wastewater service area upstream of the main plant could prove to be extremely efficient in reducing infrastructure costs. Scalping refers to removing a portion of the wastewater flow, treating it near the point of removal in a satellite treatment plant, and returning the solids to the collection system for treatment by the larger, downstream treatment plant. Not only does

this keep the treated effluent to the north, but it reduces flows to the downstream treatment plant. This may be a desirable alternative for the eastern portion of the Central Buckeye wastewater service area.

9.6 Conceptual Backbone Reuse/Recharge Piping

The reuse/recharge piping shown on Plates 1 and 2 is preliminary and conceptual, based on the data available for this study and the guidelines for recharge and reuse presented in Section 9.5. Existing and future non-potable demands for the region between the RID and Buckeye Canals within the Central Buckeye wastewater service area will potentially be served by the irrigation districts (Plate 1). No reclaimed water lines from the WRFs are routed through this potential irrigation district service area.

The following section discusses the existing, planned, and proposed future effluent management strategies for each of the wastewater service areas. Existing facilities and pipelines are in place and operational; planned facilities and pipelines are based on master plans or GIS coverages submitted to the Town by the developer; future facilities and pipelines are proposed in this study. The focus of the proposed reuse/recharge piping was to delineate the main transmission lines to areas that will be served, with the goal of connecting neighboring systems where appropriate, for maximum flexibility. In general, effluent water is moved upgradient for storage and eventual distribution to points south.

9.7 Effluent Management Strategies for Wastewater Service Areas

The original effluent management strategies proposed for the wastewater services areas in the MAG 208 Plan (CMX, 2007) are provided as Appendix D. The strategies were updated to incorporate new data on the existing systems in Central Buckeye, Sundance, Festival Ranch, and Tartesso, and the original plans were reviewed in the context of the general guidelines for recharge and reuse outlined in the previous section. Revisions to the original strategies are proposed in accordance with Town guidelines. Plates 1 and 2 provide a conceptual schematic of existing, planned, and proposed future reuse/recharge piping in the study area.

9.7.1 Central Buckeye

Status: Existing

Current Capacity: 3.0 MGD (1.5 MGD expansion under construction (completion April 2011)

Planned Buildout Capacity: 45.8 MGD

Existing Reuse: Earl Edgar Park irrigation, on-site non-potable demands, Buckeye Elementary School turf irrigation (pipeline under construction), and construction water.

Existing Recharge: None

Discharge: Currently discharging to the Arlington Canal (via BWCDD ditch)

Currently Earning Long-Term Storage Credits: No

Emergency Discharge: Arlington Canal

Future Reuse: Minimal. Irrigation districts will be supplying non-potable demands, to the extent feasible, in the majority of the service area. Future pipes shown on Plate 1 will serve major parks or planned future developments in the immediate vicinity of the WWTP.

Future Recharge: Phase I short-term: Route treated effluent north (Plate 1) and discharge to the Roosevelt Canal at Watson Road, under the irrigation district's existing Groundwater Savings Facility (GSF) permit. The resulting reduction in irrigation pumping qualifies as in lieu recharge, earning long-term storage credits for the Town. Two additional alternatives for routing water via the Roosevelt Canal can be explored: (1) wheeling the effluent via the canal to Palo Verde Road, and then routing it to a future recharge facility at the Buckeye Airport, or (2) wheeling the effluent via the canal to Johnson Road, and then routing it north to the Tartesso recharge facility. Proposed piping from the plant to the canal and a pipeline from the canal up Johnson Road are shown on Plate 1. Phase II: Negotiate a multiple use agreement with Maricopa County Flood Control District, to extend the effluent transmission piping north across I-10 and recharge the water at a potential future facility located south of the County FRS on the flanks of the White Tank Mountains.

Comments: Anticipated long-term waterlogging conditions require that effluent supplies be either reused or moved out of the area (i.e., north or south) to gain long-term storage credits. Reuse within the downtown area will be fairly minimal, unless effluent supplies the future Town Lake, or is used to irrigate large park or sports complexes. At this time, no large park or sports complexes are planned. A recharge facility to the north of the freeway, south of the White Tank Mountains, can be supplied from either the Sundance WRF or the CBWWTP. Other alternatives are discussed in more detail in Section 5.3.

9.7.2 Sundance

Status: Existing

Current Capacity: 2.4 MGD

Planned Buildout Capacity: 13.9 MGD

Existing Reuse: Golf course irrigation

Existing Recharge: None

Discharge: BWCDD canal

Currently Earning Long-Term Storage Credits: No

Emergency Discharge: BWCDD Canal

Future Reuse: Plans are in place to irrigate Rainbow Park, a 65-acre community park to be located at Rainbow and Lower Buckeye Roads. Alternatively, the park could be irrigated with RID Canal water. Additional reclaimed lines are proposed between I-10 and the Roosevelt Canal, as shown on Plate 1.

Future Recharge: The Town is exploring the potential to store water under the existing RID GSF permit to earn long-term storage credits for in lieu recharge. Treated effluent is already routed south past the RID canal for eventual discharge to the BWCDD canal, thus existing infrastructure could be used. As an alternative to this option, in lieu recharge potential can be explored with farmers located north of the RID canal; delivery of the water could be a direct pipeline from the WRF for nearby farms, or could be accomplished by wheeling the water through the canal to farmers further west. The Town would have to withdraw the water from the canal to route it north, as RID cannot serve water outside of their service area (i.e., south of the canal). A new GSF permit would have to be secured under this alternative, thus this would be restricted to large-scale farming operations. Recharge wells are proposed along the existing pipeline to the golf course (Plate 1) to provide seasonal recharge capacity when golf course demand is low.

Comments: Sundance is not completely built out; however land is a challenge for any potential recharge basins, and permitting south of the treatment facility will be limited to small volumes because of proximity to the waterlogged area. One additional alternative for future reuse is recharge via vadose zone or aquifer zone wells located along the existing pipeline that deliver treated effluent to the golf course. Recharge wells can also be placed on the perimeter of the new neighborhood directly northeast of the plant (Plate 1). During the winter season, these wells can recharge supplies that would normally be routed to the golf course.

9.7.3 Festival Ranch (Sun City Festival)

Status: Existing

Current Capacity: 1.0 MGD

Planned Buildout Capacity: 17.3 MGD

Existing Reuse: Golf course irrigation

Existing Recharge: None. On-site percolation basins are planned, but not yet constructed.

Discharge: Wagner Wash

Currently Earning Long-Term Storage Credits: No

Emergency Discharge: Wagner Wash

Future Reuse/Recharge: To comply with Town guidelines, the Wagner Wash discharge should be permitted as a managed recharge facility, although this would be considered an interim solution. For the long-term, recharge basins should be permitted and constructed to replace the Wagner Wash discharge and earn the maximum number of long-term storage credits. Alternatively, channel modifications could be made in Wagner Wash to convert the existing discharge to a linear, constructed recharge facility. A second golf course is planned within the Sun City Festival/Festival Foothills developments, which includes an 11-acre lake, and a third golf course is planned in the Festival Ranch MPC north of the CAP canal (owned by Oasis Management Resources). The future reclaimed line shown on Plate 2 deliver water to a portion of the Festival Ranch MPC north of the canal, and ties into the reclaimed lines planned for Spurlock Ranch. Locations of specific customers were not available to refine the piping network in the northern half of the Festival Ranch MPC.

The Festival Ranch WRF is located in one of the most sensitive aquifer zones within the MPA. Recharge of treated effluent or CAP water in the vicinity is highly desirable. A regional scale recharge facility near the Festival Ranch WRF that is supplied by both treated effluent and CAP water would be extremely beneficial. A pipeline to one of the areas of high potential for a future recharge facility is proposed on Plate 2.

Comments: (1) The developer is augmenting effluent supplies with CAP water, as the canal is on the northern boundary of this MPC. The connection to the CAP canal is not shown on Plate 2. (2) It is approximately 5 miles from the Festival Ranch WRF to the confluence of Wagner Wash with the Hassayampa River. Discharge to Wagner Wash will recharge within this reach and remain within the Hassayampa sub-basin. (3) A scalping plant may be useful in the northern half of the Festival Ranch MPC to generate treated effluent in the vicinity of planned golf courses, and keep untreated wastewater from moving south to the treatment plant, only to have the treated effluent pumped directly north again.

9.7.4 Tartesso West

Status: Existing

Current Capacity: 1.2 MGD

Planned Buildout Capacity: 24.2 MGD

Existing Reuse: None

Existing Recharge: Recharge basins

Discharge: None

Currently Earning Long-Term Storage Credits: Yes

Emergency Discharge: Hassayampa River

Future Reuse: Minimal reuse is planned within this wastewater service area, as the primary effluent management option is permitted recharge via recharge basins. According to the MAG 208 Plan, future reuse includes golf course and public park irrigation. According to more recent planning documents, no golf courses are included in the master plans for any of the contributing MPCs at this time, but there is a large sports complex and/or a water feature planned in the Tartesso West public parks category.

One reclaimed water loop is proposed for the future in the Tartesso West MPC, delivering water to the northwest, for athletic fields at the 20-acre sports complex, and for park and landscaping irrigation along the route.

Future Recharge: Expansions of the existing recharge basins are planned to recharge the majority of treated effluent. This is an optimal location for future recharge as the long-term predictions indicate that the WRF is located just south of the most sensitive aquifer zone in the Neck region.

Comments: (1) Within the Tartesso West wastewater service area, Montiere and the Tartesso West MPCs are located close enough to the Hassayampa River Recharge Facility to recover recharged water within one mile of the facility. This could provide an alternative or an interim solution for turf irrigation until reclaimed lines are installed. (2) The northern-most properties within the Tartesso

West wastewater service area include Montiere and the western half of Sun Valley South. It is proposed that their non-potable demands be supplied from the Sun Valley WRF, which is a short distance up-gradient.

9.7.5 Douglas Ranch

Status: Planned

Phase 1 Capacity: 1.0 MGD

Planned Buildout Capacity: 31.9 MGD

Planned Discharge: Managed USF in Jackrabbit Wash

Currently Earning Long-Term Storage Credits: Partial

Emergency Discharge: Jackrabbit Wash

Future Recharge/Reuse: The planned discharge to Jackrabbit Wash under a managed USF permit should be revised to a constructed permit (either basins or in-channel constructed facility) to maximize the return from this recharge.

With eight golf courses, and a large number of parks and storage lakes, non-potable water demand in Douglas Ranch is very high. Specific locations of the golf courses are not specified; based on the distribution of golf/park acreages throughout the individual villages, it was assumed that reclaimed lines would need to be routed throughout the development, as shown on Plate 2. The main line leaves the WRF and carries water north along a proposed highway to the northern upstream boundary of the development, where water can be stored or moved down-gradient to points west and east. A separate line routes water to constructed recharge basins to the southeast. All reclaimed lines shown on Plate 2 are proposed in this study; the location of the constructed recharge basins and future roads/freeways are based on the Douglas Ranch WRF 208 Amendment (CVL, 2006).

Douglas Ranch is located in a sub-region of the aquifer system, and is adjacent to the CAP canal. As such, a regional recharge facility near Douglas Ranch would be very desirable, supporting groundwater levels for wells serving this community and off-site properties, and alleviating some of the aquifer stresses in the Neck region. Potential locations for such a facility are to the north, west, and south of the development footprint (Plate 2).

Comments: The location of the planned recharge basins is very close to the currently permitted Hassayampa Recharge Facility operated by Summit Management. A permit to recharge here may have to be tied to groundwater pumping, and may only be capable of storing small volumes of treated effluent. Wells installed nearby would aid in securing the recharge permit.

9.7.6 Cipriani WRF

Status: Planned

Phase 1 Capacity: 1.2 MGD

Planned Buildout Capacity: 12.0 MGD

Emergency Discharge: Stone House Wash

Future Reuse: Planned reuse includes park and turf irrigation in the Cipriani and Desert Creek MPCs. The planned reuse piping within the Cipriani development shown on Plate 1 is based on the Cipriani Reuse Report (CMX, 2007).

According to the reuse plan, reclaimed water generated by the Desert Creek MPC will be used within that development. Because incomplete data are available on the location and magnitude of demands within Desert Creek, the proposed reclaimed water lines shown on Plate 1 are therefore preliminary and conceptual, and restricted to that portion of the service area south of I-10. An additional future reuse line to serve regions to the south is also proposed.

Future Recharge: The proposed Stone House Wash managed and constructed USF will not earn full credits for recharge in the natural wash (i.e., the managed portion of the facility). However, routing the water through the wash provides a desirable water feature for the community, as well as an efficient means to route water from basin to basin. The assumed infiltration rate for the constructed recharge basins is 2 feet per day, which is fairly high for a long-term recharge facility; additional recharge basins or additional reuse options may be required. The optimal location for additional recharge basins is on the northern boundary of either the Cipriani or the Desert Creek MPCs. Recharge permitted in the Stone House Wash facility may have to be tied to groundwater pumping, as it is close to the downstream boundary of the proposed expansion of Summit Management's Hassayampa River Recharge Facility.

9.7.7 Trillium West

Status: Planned

Phase 1 Capacity: 0.32 MGD

Planned Buildout Capacity: 3.2 MGD

Emergency Discharge: Hassayampa River or Wagner Wash

Future Reuse/Recharge: Planned reuse/recharge includes: irrigation for parks and developed open space; discharge to Wagner Wash or the Hassayampa River; and constructed recharge basin(s) at the WRF (from the Town of Buckeye MAG 208 Plan Amendment, CMX 2007). The planned discharge to Wagner Wash or the river should be restricted to emergency discharge only. Instead of using the wash for effluent disposal, the water should be beneficially used or routed to recharge basins. No data were available to show the location and magnitude of the projected reuse demands. A preliminary, conceptual reuse loop within the footprint of the development is shown on Plate 2; the piping follows the roadways proposed in the water and wastewater plans submitted for Trillium West.

Trillium West is located in the middle of the Neck region, the aquifer zone that will be most impacted by groundwater pumping. In the long term, when development and associated groundwater withdrawals have ramped up, future planned recharge basins at the WRF site will be well situated to offset pumping stress in the Neck region.

9.7.8 Anthem at Sun Valley South

Status: Planned

Phase 1 Capacity: 1.125 MGD

Planned Buildout Capacity: 4.5 MGD

Emergency Discharge: White Tanks Wash

Future Reuse/Recharge: Reclaimed water will be used to irrigate the three golf courses and supply storage lakes, in addition to park, landscape and turf irrigation. Planned reclaimed water lines from the MAG 208 Plan are shown on Plate 2; excess water will be recharged via infiltration basins. Proposed reclaimed water lines shown on Plate 2 will connect the Sun Valley South system with the Tartesso East system, allowing reclaimed water to be routed to a potential future recharge site from both WRFs.

Located approximately 4 miles from the proposed expansion of the Hassayampa River Recharge Facility, the Anthem at Sun Valley South WRF is a good location for local recharge basins or vadose zone wells.

9.7.9 Tartesso East

Status: Planned

Phase 1 Capacity: 1.2 MGD

Planned Buildout Capacity: 10.7 MGD

Emergency Discharge: Unnamed wash upstream of county Flood Retarding Structure #1

Future Reuse/Recharge: Reuse is planned for park, school, and turf irrigation (no golf courses are currently planned), with excess water to be discharged to an unnamed wash upstream of Maricopa County FRS #1. Storage credits would not be received for this discharge, thus it should be restricted to emergency discharge only. No data were available to show the location and magnitude of the projected reuse demands. Preliminary, conceptual reuse lines are shown on Plate 2. The reclaimed lines serve the two largest sub-regions within the MPC, and the main line continues north to ultimately deliver water to a proposed large-scale recharge facility on the flanks of the White Tank Mountains. This recharge facility would be supplied by both the Tartesso East and Anthem at Sun Valley South WRFs; connections between the two systems are proposed.

9.7.10 Sun Valley

Status: Future

Current Capacity: 1.2 MGD

Planned Buildout Capacity: 13.2 MGD

Emergency Discharge: Hassayampa River or White Tanks Wash

Future Reuse/Recharge: Proposed reuse includes park, school, and turf irrigation. No data were available to show the location and magnitude of the projected reuse demands. A preliminary, conceptual reuse line within the footprint of the development is shown on Plate 2. This reuse line will provide non-potable water to the large business parks along Sun Valley Parkway that are shown in the General Plan land use. The terminus of the pipeline is east of the development, on the flanks of the White Tank Mountains. This region was identified as having potential as a future, regional scale recharge facility, and would be a good location for recharge of treated effluent and/or CAP water. Storage, direct reuse, or distribution piping along this line can reach the southern half of the development footprint. A second pipeline routes reuse water south of the plant, to nearby MPCs that are within the Tartesso West wastewater service area. Montiere, Mirielle, and Valley del Rio reuse demands are not projected to be large, thus a reclaimed water line from the Tartesso West WRF would likely not be cost-effective. However, routing treated effluent south and downgradient of the Sun Valley WRF could be a very practical solution, serving the major reuse demands in these developments.

9.7.11 Palo Verde Road

Status: Future

Phase 1 Capacity: 0.5 MGD

Planned Buildout Capacity: 11.7 MGD

Emergency Discharge: BWCDD Canal or RID Canal

Future Reuse/Recharge: Reuse demand data are not available for this wastewater service area, and its proximity to the RID canal makes irrigation district deliveries from the RID canal a practical approach (Figure 9-2). Two options for reuse are proposed; the ultimate direction taken with the supply source from this WRF depends on the timing of development in the region, and the availability of irrigation district deliveries to satisfy non-potable demands. Conceptual reuse piping shown on Plate 1 is included in the event the irrigation district is unable to satisfy non-potable, long-term demand. The reclaimed lines serve all land uses within the wastewater service area, which includes a large percentage of industrial centers (in addition to the airport) and business parks, and extends beyond the southern boundary of the wastewater service area to include all of the business park land use. If RID can meet the non-potable demand in this region, reclaimed water could then be sent to a recharge facility at the Buckeye Airport. A proposed recharge facility utilizing vadose zone or aquifer storage/recovery wells at this location is shown on Plate 1.

Comments: (1) The Palo Verde Road WRF is located just south of the RID Canal, and serves a region that includes the Water Utility of Greater Buckeye (WUGB) and Allenville (Hopeville) Water Service Areas. Currently, only Westwind and Silver Rock developments are planned in this region, and WUGB will be the water provider. (2) There may be an opportunity to discharge to the RID Canal under their GSF permit, however the WRF is located within a couple miles of the canal terminus so the downstream irrigation customer base is small, and permit volumes are limited.

9.7.12 Gila 85 and Gila Hassayampa

Status: Future, No Developments Planned at this Time

Phase 1 Capacity: 1.2 MGD (each)

Planned Buildout Capacity: 9.1 MGD and 7.8 MGD, respectively

Emergency Discharge: Arlington Canal, Hassayampa River, or Gila River

Future Reuse and Recharge: The southern portions of both these wastewater services areas are located in the waterlogged region, thus recharge earning storage credits will not be feasible until the distant future, unless water is routed to the north. Routing the effluent north to a recharge facility is the preferred strategy because there is potential for using the Buckeye Canal for non-potable supply in these regions, as shown on Figure 9-2.

The location and magnitude of reuse demands are not available for these two wastewater service areas; the best source of information for the region was generalized land use from the General Plan. A large percentage of the land is zoned for industrial and business park land uses, including the proposed West Industrial Corridor and the Buckeye Logistics Transportation Center, which is 11,000 acres located near Arizona 85 and Old Highway 80, along the Union Pacific Railroad line. These proposed future land uses are located directly north of the Gila 85 WRF (see Industrial land use category on Plate 1). High-level planning reports have been published for the Transportation Center, but the level of detail required to identify potential non-potable water use is not yet available. The conceptual reuse piping routes non-potable supply throughout the wastewater services areas and into the adjoining Central Buckeye service area; connections with the Central Buckeye system are proposed.

9.7.13 Hassayampa North

Status: Future, No Developments Planned at this Time

Phase 1 Capacity: 1.2 MGD

Planned Buildout Capacity: 7.5 MGD

Emergency Discharge: Hassayampa River

Future Reuse: Irrigation

Future Recharge: Basins

Comments: (1) Future reuse/recharge cited above is from the MAG 208 Plan (CMX, 2007). Although no developments are planned at this time in this wastewater service area, its infrastructure can potentially be tied into the adjoining Festival Ranch system for reuse/recharge, allowing for more flexibility in managing effluent supplies. (2) There will be challenges in securing a water supply in this region. It will be necessary to maximize reuse to reduce the water demand in the AWS application, and include the impacts of any future nearby recharge facilities owned and operated by the Town.

9.8 Updates to the Reuse/Recharge Piping

The reuse/recharge piping will require updates on a regular basis as data gaps are filled, planning is refined, and specific locations for future local/regional recharge facilities are identified. Due to the conceptual nature of the piping network and the lack of data regarding the location and magnitude of demands, assigning pipe diameters was considered to be premature, providing little value. To support the first update of this planning component, it is recommended that formal reclaimed water master plans be developed for all of the wastewater service areas except Gila 85, Gila Hassayampa, and Hassayampa North.

10. CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

- Without an alternative source of water supply, the buildout population of 1.8 million people is not sustainable.
- The Town can address the sustainability issue by (1) securing additional sources of water supply, (2) reducing densities and the extent of developed acreages, or (3) reducing demand through conservation.

10.2 Recommendations

10.2.1 General

- More detail and more categories should be included in the land use plan, specifically parks, golf courses, and schools.
- Develop a template for the water/wastewater master plan submittals, to provide consistent data and the level of detail that the Town will need for updates.
- Waterlogged Area Water Treatment Plant recommendations: additional modeling (worst-case), water quality feasibility study, legal and permitting feasibility, formal siting study, evaluate technology available for treatment.
- Meet with developers who currently have a pending (or conditional) AWS application to discuss alternatives.

10.2.2 Recharge

- Actively engage in discussions with Surprise and CAGRD to discuss long-term plans for recharge, recovery, and replenishment at the Tonopah Desert and Hieroglyphic Mountains Recharge Facilities. Lobby for a large percentage of replenishment (vs. recharge stored for other entities) at these two facilities. At a minimum, secure an agreement that CAGRD will store all of Buckeye's replenishment water at these facilities.
- Revise development agreements to require early permitting of recharge facilities for treated effluent.
- Require vadose zone recharge wells (or aquifer zone recharge wells) in the odor control buffer zone around the WRFs.
- Perform site-specific feasibility studies on the three locations that ranked highest in the recharge assessment: the southern flank of the White Tank Mountains, the western flank of the White Tank Mountains, and the regions on the boundaries of the Douglas Ranch property.

10.2.3 Sustainability

- Formally approve the sustainability criteria and revise the population projections for the Town.
- Add water quality to the sustainability criteria.
- The cost of reliance on CAGRD replenishment should be rolled into future studies of the actual cost to procure and serve water to the Town's residents.
- Research the long-term potential for reliance on irrigation district deliveries.
- Discuss reductions in density and residential land use acreages with developers; identify where adjustments can and should be made; revise master plans.
- Update land use plan acreages/densities with the updated master plans for the major developments. Require GIS coverages of the land use from the developer for streamlined updates.
- Implement tracking procedures to quantify the impacts of conservation. Expand on the Conservation Plan to include milestones and goals designed to increase conservation.
- Decision: does the Town wish to rely on replenishment of groundwater as a future source of supply?

10.2.4 Effluent Reuse and Recharge

- Require all WRFs to install valves, outlets, and filling stations to supply construction water.
- To support the reuse plan, it is recommended that formal reclaimed water master plans be developed for all of the wastewater service areas except Gila 85, Gila Hassayampa, and Hassayampa North.
- Review and revise the general guidelines for recharge and reuse; formally approve.
- Develop reclaimed water master plans for each of the individual wastewater collection sub-basins.

10.2.5 Sustainability and Water/Wastewater Infrastructure

The Water/Wastewater Infrastructure Master Plan relied on land use and the General Plan for future demands and modeling. The sustainability assessment indicates that alternative sources of water supply must be identified, and/or population densities and residential acreages distributions must be adjusted. This disconnect must be resolved, and the demands included in the water and sewer modeling should be revised accordingly.

- Incorporate the results of the sustainability analysis and existing master plans for developments. New master plans for develop should be incorporated also.

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APPENDIX A

Original and Revised Scope of Work

APPENDIX B

List of Master Plans and Developers' Reports

APPENDIX C

Town of Buckeye Well Summary

APPENDIX D

Existing, Planned, and Future Effluent Management from the MAG 208 Plan Amendment (CMX, 2007)